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THE PATH OF EVOLUTION

PEMBERTON

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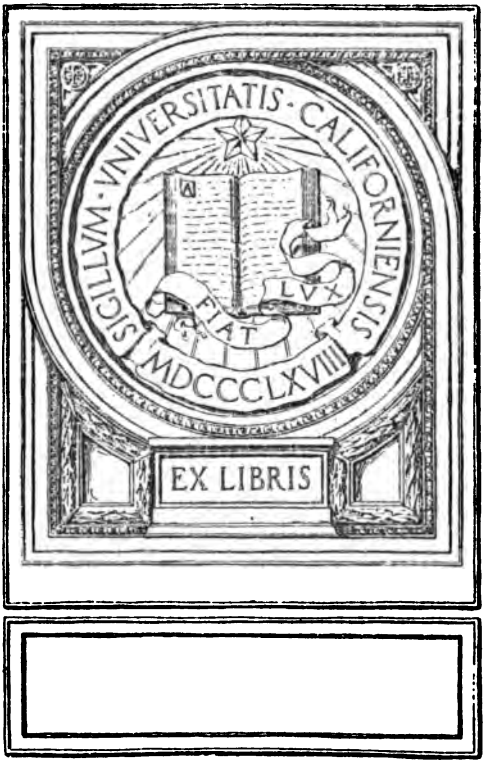

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THE PATH OF EVOLUTION

THROUGH ANCIENT THOUGHT AND MODERN SCIENCE

BY

HENRY PEMBERTON

MEMBER OF

AMERICAN PHILOSOPHICAL SOCIETY
ACADEMY OF NATURAL SCIENCES, OF PHILADELPHIA
HISTORICAL SOCIETY OF PENNA., ETC.

"Excelsior Cœlo est, et quid facies?
Profundior inferno, et unde cognosces?

PHILADELPHIA
HENRY ALTEMUS COMPANY

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Dedicated

TO THE MEMORY OF

MY BELOVED WIFE,

AGNES. W. PEMBERTON,

AT WHOSE EARNEST DESIRE

AND WISHES OFTEN EXPRESSED

THIS BOOK WAS WRITTEN.

421277

PREFACE

THE sketch here given of the evolution of knowledge and the doctrine of the evolution of life is the effort to place in a connected historical relation the questions discussed and partly answered in my home. To those who are versed in the several sciences touched upon the treatment thereof may seem to be too superficial, dealing mainly with the beginnings of principles and teachings that even a child might know. But it is the beginnings of things that are often least well known. The questions that a child might ask the wisest man can scarcely answer. On the other hand, the problems of the Ether and of Gravitation are yet unsolved, and by many men are thought to be insolvable.

The views taken of man's place in nature and his relation to the Higher Power are those, I believe, that are held by most scientific men; but since no two men think exactly alike a general concordance in thought is all that can be looked for.

The "Path of Evolution" was written nearly five years ago. Domestic sorrows and personal illness caused it to be laid aside for several years. A few pages descriptive of late discoveries have since been added.

H. P.

1947 *Locust Street, Philadelphia.*
November, 1902.

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INTRODUCTION.

THE desire to obtain a better knowledge of the unknown is inborn in the human mind. The veriest savage, ignorant of the causes of all phenomena, yet ascribes an animating spirit to the force that the waves exert, to the wind he feels, or to the swaying branches of the trees he sees around him. To liken the cause of their movements to that vitality which he is dimly conscious of in himself is for him a sufficient explanation. In the olden days of Greece the minds of men peopled the woods, streams and ocean with beings more or less like themselves, but more spiritual in their nature. The Dryads, Nymphs or Demigods dwelt therein, ruled the elementary forces, and thus satisfactorily accounted for the phenomena of nature. As men grew wiser they recognized that these beings were only the objective creations of their own thoughts; they had given to "Airy nothings a local habitation and a name," yet they despised the search into the phenomena of Nature, since they believed Matter was in itself ignoble, and the study thereof degrading. They had an exaggerated conception of the power of the mind and of its capacity. Most men believed that the *ideas* of things existed before their realities, were of a purer, and therefore of a nobler nature, and that the mind of man offered the only field for study. Ignorant of all relative knowledge, they yet hoped to discover the secret of existence; to know the ABSOLUTE—THE UNCONDITIONED—by introspection, and by converting their subjective thought into objective theories to obtain true knowledge. Metaphysicians still so try, will continue so to do, but will try in vain. So long as men employ *deductive* reasoning only, from a-priori convictions, no evolution of real knowledge is possible.

With the method of *inductive* reasoning came gradually the accumulations of observed facts, and the discovery that these facts were not the accidental result of irregular causes, but were the consequence of definite, uniform actions or conditions. Men found that these actions or conditions indefinitely repeated would always produce the same result. To them were applied the term "Laws of Nature." Usually these laws do not explain the cause of a fact or occurrence, but only assert its invariability. The explanation of a phenomenon generally consists in showing the existence and its connection therewith of earlier phenomena, or the exertion of earlier forces of wider generalization than the one observed, thus linking the phenomena together into systems of greater or lesser similarity. Often this systematic grouping is accepted as an explanation; as such it is valuable, and is sufficient for practical purposes; what is called the "Study of the Sciences" usually goes no further. If an explanation is sought for still further and further back, it is ultimately found that alternatives are presented, each of which is beyond our apprehension, or that we cannot form even in idea an explanation thereof. We have approached the question of a FIRST CAUSE. It lies beyond the limit of our faculties.

In order rightly to understand the philosophy that modern science teaches, and the difference between it and the metaphysics and philosophy of olden times, a short sketch of the decline of learning in the Dark Ages and its subsequent rise into the Scholasticism of the Middle Ages is necessary. The conservation of the literature of antiquity by the Arabs and the Hebrews, until the Clergy in Europe were capable of utilizing it, is included therein.

The gross ignorance of the laity and clergy throughout Europe in the 7th, 8th and 9th Centuries was long-continued. Charlemagne in the end of the

8th Century ordered the opening of schools, but more than two centuries again passed away before learning had made much progress. A rapid survey is therefore made of the first stage therein—the *Philosophy of Scholasticism*, apart from its merely dialectic teaching, but embracing the conflicting views of Plato and Aristotle, the ideal existence of Form and Matter, and the foundation upon which rest the diverse doctrines of the Realists and Nominalists.

The emptiness of scholastic learning caused **Roger Bacon** to revolt against such teaching. He was wise beyond his time, and suffered, as such men often suffer: a wasted life and long imprisonment as a reward for his premature wisdom.

The philosophy and learning of the "Schoolmen" produced no useful results. All persons then believed in "a-priori" reasoning only, and looked with contempt upon the investigation of Nature and upon empirical research. The belief in Alchemy and in Astrology was widespread and general. Alchemy was pursued chiefly in the search for the "Philosopher's Stone," or power of transmuting other metals into gold. Astrology was sought for to render its magic aid. Yet these false sciences, by causing men to experiment, to watch phenomena and observe the heavens, taught mankind far more than a thousand years of Monastic study and Scholastic teaching had accomplished.

The introduction of the art of printing soon witnessed, if it did not produce, the downfall of Scholasticism. The greater facility in obtaining books awakened men's minds to a desire for the acquirement of knowledge. As milestones on the path of progress short sketches are given of the life and work of a few distinctive men, each of whom in turn has been the centre from which new learning started. All of these great men, though original thinkers, followed only the method of a-priori reasoning. Experimental research and critical observation as yet scarcely existed, possibly with the exception of the work of Copernicus, who appears to have well studied the heavens.

Earlier in date, but later in the actual advancement of human knowledge than Descartes, **Lord Bacon** formulated the method of the Inductive Philosophy, and established the use and the dignity of the study of Nature. Bacon preached better than he practised. He made few practical investigations, and never accepted the Copernican Astronomy that Galileo had so ably demonstrated.

With **Galileo** a new school began. To the ability of a Mathematician, which most of those already mentioned also possessed, he added the power of accurate observation and the careful consideration of the facts obtained. With him began the practical application of inductive reasoning.

With SIR ISAAC NEWTON may be said to have commenced nearly all that we know of Modern Science. To his discoveries of the compound structure of a ray of light, the theory of colors and the laws of gravitation, are due the facts which establish the generalizations that unite our planet with the whole universe. They prove that of the thousands of millions of stars that exist, each is undoubtedly a central sun in planetary systems of worlds somewhat like our own; which are governed by the laws that govern ours, and probably have sentient beings on them as wise or possibly far wiser than ourselves.

In treating of the *Interstellar Ether*, whose existence Newton postulated as essential to the theory of light and probably that of gravitation, a disproportionate space is devoted, from the desire to call attention to the assured existence and probable nature of that almost incomprehensible substance: the carrier of all Energy, that is within and through all matter, that extends beyond the most distant Star, that brings us light and life, but of which we really *know* almost absolutely nothing. The belief in the existence of the Ether, advocated by Democritus nearly 500 years B. C., has of late years grown into general acceptance, since it serves to explain the transmission of light, heat and the electric waves. The Kinetic Theory of Gases, now firmly established, showing the molecules of all gases to be in constant, rapid, translatory motion, producing thereby the effects of the pressure and expansion of gases, has a strong analogy with what is supposed to be the *Atomic* structure of the Ether. Our atmosphere, a gas, while preserving the individual motion of its molecules and the statical pressure of fifteen pounds to the square inch upon our bodies, as upon all substances, is yet insensible to us so long as the pressure on all sides is alike, yet it is also the *medium whose vibrations cause sound.* All production or conveyance of sound ceases with the withdrawal of the air. Nature is parsimonious in the employment of her Ministers. She requires of the atmosphere not only the service stated, but makes it also the reservoir of the oxygen we breathe, the storehouse of carbon dioxide, kept therein until wanted for the life of the growing plant, the supporter of combustion, the distributor of water throughout the land, and the conservator of heat; while the winds thereof are their own conveyers of physical motion, are the forces that move the waves, wrestle with the forests, and scatter seeds and pollen throughout the land. So also the Ether should have many duties. It is the medium through which Life is given; whether only through the light and heat it brings, or whether in addition thereto its atoms take part in inducing new groupings of the existent chemical molecules, are questions that are as yet beyond the result of human investigation.

Had the brilliant mind of J. CLERK MAXWELL (1831–1879) been spared to the world a few years longer, he would probably have added as much to our knowledge of the Ether as his genius had done to the theories of Electro-Magnetism. (See his articles "Atom, Attraction, Ether," etc., Encyclopædia Brittanica. 9th edit.)

When men began seriously to investigate phenomena under the light of inductive reasoning, almost the first step was to discard the old views of the composition of Matter and the vague four elements of the Alchemists: Air, Water, Earth and Fire, that lent to substance its properties. Then was substituted therefore the definition of an element in its chemical meaning: "A substance that cannot be separated into its constituents." This definition conferred individual characteristics upon the atoms postulated by Democritus that by him were considered without properties other than having motion; the four elements: Air, Water, Fire, etc., furnishing the "accidents" that distinguished the kinds of matter. From the true conception of the elements soon arose that of their molecular groupings and the laws of chemical affinity;

the false but plausible theory of Phlogiston interposing, and delaying for generations the true explanation of combustion, of respiration, and of numerous other phenomena that are connected with free oxygen and with its many compounds.

Upon the knowledge obtained through the Science of CHEMISTRY nearly all the progress made in other sciences depends. Through it we have learned of what the animal, plant and mineral realms are made, of what our globe is composed, and, most wonderful of all, with the help of spectral analysis, we are taught whether the far distant stars are moving towards us or away from us, of what elements these glowing orbs are composed, and we have even discovered in the sun certain elements before they were known or met with on this earth. Chemistry has also proved to us the indestructibility of Matter. We can make or break up many compounds; they are groupings of atoms into molecules that can be separated again into atoms, but the atoms can neither be made nor can they be destroyed. They are imperishable. In like manner Energy can neither be made nor can it be destroyed. The changes that can be induced in its form or manifestations are endless, but man cannot bring it into being from nothing, nor can he annihilate it.

Any change in chemical combinations is always attended with the development or the absorption of heat, and also with manifestations of electrical phenomena. Heat and electricity themselves induce chemical changes. These relations indicate that chemical affinity, like heat and electricity, is dependent upon the properties of the Ether, but what chemical affinity *is*, or *why* it acts, it is almost impossible to conceive. The possible cause of Static electricity and of electro-conductivity—the Ions of the Ethereal molecules—has been suggested by the Writer. A description of the generation of the Kathode and of the Röntgen rays has also been included.

The Geogony of the earth covers too wide a field to be more than merely named. A suggestion is made of the probable origin of carbo-hydrides from inorganic changes. Since writing this M. Moissan has shown the probable production of Petroleum in the earth from metallic Carbides.

The fleeting view thus taken of the phenomena of the inorganic world shows that all knowledge thereof has only been obtained by the close observation of countless individual facts. By classifying them into groups of more or less general similarity, and noting their accordance with or divergence from some common principle, mode of action or of force, we think we understand their nature and what they are. But when we try to know this principle, action or force, what *it* is, we find it is beyond our comprehension. The phenomena are co-related; each involves the co-existence of other phenomena that precede or follow it. Their connection and their sequence are learned, but sooner or later we are led to ultimate causes that are past understanding. This is the case with all we know of the mineral or inorganic world. It is even far more so with the organic world, when we look upon that which has Life.

The truth of the doctrine of the Evolution of Life, including the Origin of Species, has ceased for years to be a debatable question among men of scientific learning. Though from the nature of its subject it is incapable of mathematical demonstration, yet the facts supporting its truth are so convincing to the mind and so well established that, like Newton's law of gravitation, the theory is now beyond discussion. Like Newton's law, also, this doctrine at first met with violent opposition. Each changed and overthrew old, long-established, orthodox beliefs; for over one hundred years Newton's theory of gravitation was rejected by many; was considered to be atheistic and impious. From similar reasons, about fifty years ago, intense indignation and excitement was caused by the publication of the "Vestiges of Creation," an imperfect theory of natural evolution. The opposition to it has long since died. The theory of the Evolution of Life and the Origin of Species, supported by the writings of Darwin, Wallace, Huxley and others, has been accepted and defended even in the pulpits of our land.

To many persons who have been educated with different ideas, even especially with those studying only certain branches of science, the break between the old train of thought, or what was believed to be true, and the teaching of modern science is so great as to be bewildering. They have to discard from their minds so much which has proved to be erroneous that it would seem that nothing might be left. The neglect of all philosophy other than that contained in the proximate principles of Chemistry, Physics, Biology, Medicine, or whatever else might be the immediate subject of study, leaves its students in possession of an *imperfect knowledge only* of the secondary causes. Each branch of Science, being dissociated from other branches, prevents that generalization of knowledge upon which the Philosophy of Evolution, as well as all other Philosophies, must be grounded. In consequence thereof many students of the sciences are apt to drop into a shallow Positivism, or into what they mistake for Agnosticism, but which is really only mere negation founded on Ignorance. On the other hand, many people who desire to know the principles of Evolution, among them often women of clear and cultivated minds, are driven from its study by hearing that it is pure Materialism only; that it may destroy the belief they have and give nothing in its place. That such a view is erroneous is here endeavored to be shown.

The problems that present themselves in considering the Doctrine of Evolution, and what it is that constitutes Life, lie necessarily within the limits before described, that of the study of *secondary* causes, but constantly approach that line which *cannot be crossed.* Yet in striving to learn what we cannot learn, we are often able to know better that which is within our reach; to recognize how all the processes of Nature are intertwined; how the properties of one division of substances are dependent upon or available for the continuance of other phenomena of a widely different order. We can see that this little globe is a Cosmos, in which the imponderable and the ponderable, the inorganic and the organic, the plant and the animal, the living and the dead, are concatenated: each link therein an essential part of all. Many of these relations we know, of many others we still are ignorant.

Haeckel, Huxley and many other Bioligists some years ago rejected and even ridiculed the existence of a Vital Force, believing that all the phenomena that organic structure and that Life exhibit are sufficiently explained by the laws and actions of chemical affinity, and therefore that the existence of any force called Vitality is unfounded and superfluous. This view has lost credence to a great extent within a few years past, by the disproof of the main foundation on which it rested—the doctrine of Spontaneous Generation. The closer relations that have been established between the phenomena of Physics and of Chemistry, the conservation of Energy, and the acceptance of the existence of the Ether, have widened the field of investigation, and even led to the possibility that what were considered the "Ultima Thule" in chemical science, the atoms, may be a compound, a product of the Ether. The phenomena that Life offers are more than those of Chemistry and Physics.

The examination of the manifestations of Life should begin with its development in its simplest shapes, the "Monera" of Haeckel: those forms of which it is impossible to say whether they are plants or are animals. Among them, or closely related thereto, are the Bacteria and similar low forms of Life. The evil and the good that they give rise to are pointed out. In what way Life manifests itself and is transmitted without change in the lowest forms of beings, by division or gemmation, and in the progressively higher forms by asexual and sexual generation, is shown by describing in detail the processes in the lowest life, in PLANT life and in flowers. The conditions that give rise to the variation of species and the benefits and evils from atavism are briefly noticed. The nature of the Fungi family and the curious composite state of Lichens are considered. The all-important part held in Nature by the Chlorophyll cells in the leaves of plants, without whose functions all plant and animal life on this earth would soon cease, have received attention, and partial explanation of their action is given. The florescence of plants, the fertilization, the germination and growth of the seed into the plant, are shown to be the expenditure of Energy from the Ether, stored up in the plant and seed until needed by the plant's new growth.

The higher development of life in ANIMALS has been but lightly touched upon; changes produced by incubation in an egg, and a few remarks on Embryology, being all that was thought desirable to give. Throughout all the phenomena described, the Energy carried by the Ether is believed to be the direct acting power.

A slight sketch is given of the men who preceded Darwin that held ideas concerning the Evolution of Life. The manifestation of intellect is next considered, and the change in the line of evolution that ceasing to modify the *body* expended itself on the growth of the *brain* that was needed for the development of the higher energies brought by the Ether, producing, finally, rational Man. The traces of his once arboreal life are yet borne by him, and from time to time reappear, through atavism, evidences of his once savage and even brutal nature. If men were early taught to recognize these traits for what they are, and seek to conquer and remove them, many a worthless life might become a worthy one.

The narrative given of the Evolution of Knowledge has been thus far absolutely from the point of view of strictly scientific observation and empiricism; phenomena have been considered as manifestations of force and energy in various forms, and under laws or conditions of exact and constant uniformity, open to investigation and to more or less perfect understanding. It is the only way that the Path of Evolution should be or can be studied.

Yet in all directions that we seek to pass we meet with the evidences of the existence of a wise, intelligent, all-sustaining VOLITION, in whom all things begin and end, who is the source of life and the giver of all good!

The Philosophy of Evolution teaches a different Teleology from that of the metaphysician or theologian. It shows that the arrangements for life and happiness for the good of all, are unchangeable. The laws instituted must be learned and obeyed. The actions thereof are invariable, not varying capriciously nor changed from any cause. It is for us to learn them and obey them, for ignorance or good intention will not excuse, nor save from the consequences of their violation. The laws that govern mental and moral action are like the physical laws—to be learned and to be obeyed.

The question, "Is Life Worth Living?" for animals or man, is answered by a rapid glance at the life of each, beginning with the undoubted joy of living by the young of all animals, giving place as they grow older to the duties of providing for themselves and for their young, and to the parent's care and love for its offspring. In man the youthful days are much the same—the animal pleasure in merely living! As childhood passes with the youth away, the duties of life begin, and with the duties come the pleasures, too—if pleasure-seeking be not the only goal.

The traits of similarity and of difference in the young girl's character from that of the boy's are noticed, and the distinguishing characteristics of woman's psychical nature fitting her for life's duties are described. The mutual attraction the opposite sexes have for each other plays an important role in the life of each, causing the romance of love and most of the Poetry of Life.

The problems offered by the existence of Sin and Death find a better solution in the doctrine of Evolution than can probably elsewhere be given. Death is unquestionably an integral and essential part of the plan of existence. The former finds a partial solution in atavism, and it is trusted will find a complete one in the ultimate results of further and perfected evolution.

The course of life is not intended to be free from troubles. The full development of the *physical* frame is in consequence of the exercise of its muscles and faculties; unless the organs are brought into use they will not strengthen, and if quite disused will be atrophied or die. So it is with the *mental* and *moral* faculties. The greater the intelligence, and the greater its capacity for advancement and improvement, so much the greater is its need of a higher stimulus for the onward course. The lessons of life are to be learned more by practice than by precept.

The Philosophy of Evolution can teach nothing positive concerning a future life more than other philosophies can teach. To discuss it even lies outside of its province. Nevertheless, this may be said, The Path of Evolution clearly shows that the course of all life here is an advance from a lower state of development or of existence towards a nearer perfect development and a higher existence. If our lives are so passed here that the personality acquired is worthy of a nobler and a wider field, it would seem but natural "when the spirit shall return unto God who gave it" that its evolution shall continue into a higher life, for the doctrine of Evolution that Science teaches is that the Intelligence and the Will was not the *Brain that died*, but that the brain was only the workroom and the dwelling-place of part of that Intelligence and Will that NEVER dies.

THE PATH OF EVOLUTION

CHAPTER I

THE DOWNFALL OF THE ROMAN EMPIRE IN THE WEST AND THE EXTINCTION OF LEARNING—THE OPENING OF THE SCHOOLS BY CHARLEMAGNE—THE ARABIAN AND THE JEWISH PHILOSOPHY.

> "The tower that had long stood
> The crush of thunder and the warring winds,
> Shook by the slow but sure destroyer Time,
> Now hangs in doubtful ruins o'er its base,
> And flinty paramids and walls of brass
> Descend. The Babylonian spires are sunk;
> Achaia, Rome and Egypt moulder down.
> Time shakes the stable tyranny of thrones,
> And tottering empires rush by their own weight."*

THE empire of Rome, with its civilization and its learning, was far advanced on the downward path to its ultimate ruin when, in 325, Constantine accepted Christianity as the official religion of the State. The city of Rome had ceased in Diocletian's time to be nominally the seat of government. In 330 Constantine established the Imperial City to which he gave his name, and to which he transferred much of the riches of Rome and many of its most prominent citizens. Rome was no longer the literary centre. Most of the Latin authors of this and of the next century were Gauls by birth and habitation. The Greek language, which had been read and spoken in Rome for several centuries by all persons of culture, began to pass into disuse in the western branch of the empire. In Constantinople it continued to be the language of literature, though the transactions of the government were officially in Latin.

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* John Armstrong. 1708–1778.

Throughout the first three centuries of the empire the doctrines of the various sects of philosophy had been taught in the schools of the several great cities, especially in those of Athens and of Alexandria. The most prominent among the philosophies were those of Plato, of Aristotle, of Epicurus, and of the Stoics; the first especially, whose teachings preceded those of the founder of Christianity by over three hundred and seventy years, had exerted and continued to exert a dominating power over the minds of learned and of thinking men. To its influence and to that of the Stoics was probably due the introduction into the Fourth Gospel of the doctrine of the Logos. The writings of Philo Judæus (born about 20 B. C. and died about 50 A.D.) had brought the Greek philosophies—already known to the Hellenistic Jews—more vividly before them. The Stoic philosophy—a materialistic, partly pantheistic view of nature—placed the ethical life of man and the pursuit of virtue upon an eminence to which no other pagan philosophy had ever attained. In Rome it dominated the life and writings of the Emperor Marcus Aurelius Antoninus. Soon after his death it became absorbed into neoplatonism and lost its separate existence.

The Epicureans, followers of Democritus and of Epicurus, taught that all nature was the blind result of chance, the haphazard, fortuitous impact of the atoms, without any governing cause, either efficient or final. Being thus atheistic, the philosophy had little or no influence upon earlier or later religions. Yet its atomic theory of the physics of space is otherwise a marvellous anticipation of the thought and science of modern times.

The doctrines thus taught by the various philosophies were also practically the religions of their adherents, except among the Jews and the early Christians. Some of the former added, as Philo did, the Platonic and Stoic philosophies to the teachings of the Mosaic Scriptures; the latter—the Christians—either rejected the philosophical religion of their teachings absolutely as of no value, or accepted them in part only and assimilated them into the Christian dogmas, giving birth to the Gnostic, Docetic and countless other heresies that for centuries distracted and divided the Christian church. It was not until the latter part of the ninth century that the church began to teach in its schools the principles of philosophy apart from, but by the side of, its theological learning.

The repeated invasions of the barbarians had, by the end of the fifth century, destroyed the Roman Empire. Rome itself, conquered and sacked, over and over again; the country around it—the campagna—grown pestilential and uninhabitable from the filling up of its drains and watercourses, seemed to await the fate of Babylon or Carthage, so that even its ruins might have perished and its site been lost. The conquests of Theodoric the Great, King of the Ostrogoths, known in the Teutonic legends as the half-mythical "Dietrich of Berne," gave for a time the promise of better days. Under him Italy again became prosperous. The arts revived, the advance of the semi-savage Franks under Clovis was checked, and peace and civilization seemed again established. But his successors did not possess his abilities; they could not defend what he had conquered! After sixty years their kingdom fell; the invasion of the Lombards completed the conquest of Italy, and the night of the Dark Ages shut down on Europe. For six hundred years all learning ceased, and much that had existed was forever lost.

In 590 Gregory the First had been elected Pope. This man, born of a patrician family and of high natural abilities, succeeded in keeping the Lombards away from Rome itself. Sismondi says: "It is difficult to understand why Rome was not taken by the Lombards when Alboin made the conquest of the rest of Italy." *

Gregory's energies were devoted solely to the progress and advancement of his church. Besides establishing the Orthodox faith in Great Britain, he succeeded in converting to its doctrine many of the Arians (Unitarians) of Italy and Spain, who, in common with the Gauls, the Ostro- and the Visi-goths, and all the northern barbaric nations—except the savage and orthodox Franks—had for centuries adhered to that heresy.

The writings of Gregory show that he held in horror and aversion the classic literature of the past. The evidence that he instigated the destruction of the monuments and temples of antiquity is very doubtful. Equally without proof is the common belief that he ordered the burning of the Palatine Library; but the fact of his contempt for learning is unfortunately too well established.

"Erudition consisted then, as it did for centuries after, only in the recognition of the dogmas that a

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* Histoire des Republic Italiens, T. 1., p. 100.

Christian should accept, and of the heresies which he should flee from. Having heard that Didier, Archbishop of Vienne (formerly one of the most literary towns of Gaul) had undertaken to reopen the schools—he himself giving lessons in grammar—Gregory wrote to him: "My brother, they write me what I cannot repeat without shame—that you have thought it right to teach grammar to certain persons! Learn, then, how serious, how frightful it is that a bishop should treat concerning things that even a Layman ought to be ignorant of! If it can be shown to me that the report is false, and that you have not been occupied with such frivolities, with secular literature, I will return thanks to God that He has not let your heart be soiled by the impure felicitations of the perverse." * Such language indicates the temper of the time!

The heresy of the Montanists, aided by the poverty and desolation of the land, drove thousands into the desert and wild places to lead a life of asceticism, fanaticism and idle introspection, following therein the doctrines of the Essenes and the Therapeutæ rather than the Christian teachings. Other countless thousands gathered into little knots and founded monasteries throughout the eastern and western empires, even in Rome itself. The inmates thereof practiced the self-denial and asceticism that they pro-

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* Haureau: Philosophie Scholastique.

fessed; they confined themselves to the clothing absolutely necessary, and to a diet of the simplest and poorest kind, barely sufficient to nourish life. This regimen was well fitted to stimulate their visionary fancies, while it reduced their minds and bodies to a condition that was under their better self-control. Their daily labor in cultivating the land, or in servile work, provided them with food, and other wants they had none.

The practice of an ascetic life has in all countries, Pagan and Christian, generally been considered the evidence of superior virtue, and has conferred sanctity upon its votaries. Upon this account as time passed on and the monasteries increased, they received many donations from those entering their orders, and rich bequests from those who had died in the faith. The orders having perpetual succession seldom lost that which they had once received. They rapidly increased in wealth, so that their inmates were relieved from the necessity of menial work. With their increasing wealth the natural consequences followed. Their humility and asceticism were replaced by pride, arrogance and luxurious living. The other and worse scandals of later monastic life need not be dwelt on here.

The ample leisure thus afforded in their secluded lives might have properly been devoted to study;

but the illiterate masses who filled the cells were without education. Their time was largely taken up with the exercises of devotion; the few who could read and write were occupied in recording the visions, miracles and the partially fabulous lives of their fellow-devotees, who, after death, were often canonized, and entered into the hagiography of the saints. A few—the very few of them—preserved copies of the Greek and Latin classics. In the western empire the knowledge of Greek practically died out. Latin was preserved in a more or less imperfect form by the necessity of employing in the church services a language that might be equally sacred and at least partially intelligible to the Lombard, the Gaul, the Burgundian and the Frank. The popular or vulgar dialects of each nation were alike unintelligible to the others, especially in France. As the years succeeded each other, the Latin became more and more corrupt; and as the times of the grammarians became more remote, the last remembrances of learning seemed to die out. A few monks might be found in the depths of some of the monasteries who had received and preserved in secret some slight notion of literature; but the intellectual state of the multitude both of the clergy and the monks was that of thoughtless, careless ignorance.*

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* Historie de la Philosophie Scolastique, par B. Haureau, Membre de L'Institute. Paris, 1872-1880, en Trois Tomes, T. l., p. 5.

The decadence of morals had followed the neglect of study. Idleness had served to nourish vice. The people that had once distinguished themselves in the world had slowly degenerated, so that they seemed to have lost the instincts of morality. In Italy, as well as in Spain and Great Britain, a little more learning was preserved than in France. There were a few schools in which the masters read the classics. Charlemagne had visited these, and he determined upon the restoration of the schools throughout his realm.* In 788 he wrote to the bishops and abbes a circular letter stating: "We consider it useful that in the monasteries and dioceses committed by the favor of Christ to our administration there should be added the study of letters, to the scrupulous observance of the regular life and the practice of the holy religion; for, if it pleases God that we should live rightly, we must not neglect to please Him also by speaking rightly." Thus began the first efforts towards the revival of learning in Europe.

Sismondi,† describing the mode of life of the Italian "Seigneur" in the 9th and 10th centuries, states that they lived shut up and apart in their castles, surrounded by their peasantry only. They felt no need of cultivating their minds to shine in society, for society they had none; nor of living in splendor, to impose only on their inferiors. Their pleasures and their luxuries were arms and the chase. The education of a gentleman consisted in being taught how to manage a fiery steed; to handle with skill a heavy lance or shield, and to bear without fatigue the weighty cuirasse; but it did not require that he should speak with elegance or write correctly. The vulgar language had become something very different from Latin; yet the latter was the only language that could be written. A vast number of contracts made by gentlemen have been preserved, drawn up by the scriveners in such barbarous Latin that it is almost impossible to recognize it as such. The buyer, the seller, the witnesses were generally all gentlemen, but, not knowing how to write, made crosses for their signatures, which were attested as such by the scrivener.

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* In 800 he was proclaimed emperor by the people and magnates of Rome, thus re-establishing the empires of the West, consisting of the whole of Germany, France and Italy.

† Sismondi: Republique Italiens. T. I, p. 33.

Haureau states: "In France the laity had at first only a repugnance for study, but afterwards a contempt for it. They were then led by their vanity to refuse even to learn to read. To teach them the history of their religion it was necessary to cover the walls of the churches with paintings. This became their only literature."

As the schools were opened, however, in many towns, crowds of the young ecclesiastics thronged to them eager to learn, so that the schools in such communities became flourishing. In other places illiterate and indolent bishops violently opposed them; declared themselves the enemies of all learning, saying that it was a sin even to read the Scriptures; they scorned as meddling mischief-makers those who spent their time meditating over the law of God. They were not enough in numbers, however, to stop the progress of the schools. In vain they groaned, declaimed and threatened. The people in every town solicited a school; when the request was refused, they complained to the Bishop of bishops—the Pope—Eugene II. (824–827), who ordered that in all the dioceses, dependent towns, and wherever it might be needed, masters should be appointed to teach belles-lettres and the liberal arts. "Thus was revoked the labor and instructions of St. Gregory, and the door was opened in the church for teaching to the youth among the Gauls the writings of the ancient philosophers, who were well named the Patriarchs of the Heretics. Then, after some centuries of arduous work by the poor clerks in restoring to available shape the literature of the past; after the schools had grown beyond the study of grammar and rhetoric into the higher study that we now call philosophy, the church, condemning the work of its own hands, lighted up the funeral pyres to precipitate therein both masters and pupils." *

THE ARABIAN PHILOSOPHY.

While Europe, from the beginning of the seventh century until nearly the middle of the ninth, sank deeper and deeper in the mire of ignorance and darkness, a new power arose in Arabia, that for two or three generations seemed as if it could only serve to increase the gloom. In the year 571 Mohammed was born in Mecca. He died in 632, after having established by the sword his dominion and his faith over the people of his own land, and attacked, at first unsuccessfully, the Byzantine Empire. His death occurred when he was preparing to renew the attack. This war his successors carried on against the Greeks and against all the border lands of Arabia, driving back upon themselves alike Pagans, Jews and Christians. Many of the believers in Islam, the Bedouins and other Nomads, were as ignorant and wild as the northern hordes that had swept over and possessed the Western Empire. It might, therefore, with reason be expected that the new faith would destroy with its advance all existing knowledge in the lands it conquered.

With Mohammedanism, as with Christianity, many

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* Haureau : Philosophie Scholastique. T. 1, p. 15.

heresies arose before the end of its first century. Each had its origin in the same cause: some independent spirits attempted to explain doubtful or obscure passages in their several Scriptures, or to make clear the exact significance of dogmas derived therefrom. Thus arose various schools that interpreted the Koran diversely. The advocates of the several schisms learned to clothe their arguments in dialectic forms that philosophy furnished, so that they gradually changed from being schools of theology only into schools of philosophy.

The first heresy was that of the Kadrites, who held the doctrine of Free Will: that man alone determined his own actions, whether good or evil. To them were opposed the Djabarites, or absolute Fatalists: that man had no power whatever in himself. This doctrine would have accorded well enough with the orthodox belief if its author, in his desire to avoid attributing to God the qualities of the creature, had not made of Him an abstract being, devoid of all attributes and action. Against both of these arose the Cifatites, who, taking literally the words of the Koran regarding the attributes of God, fell into the grossest anthropomorphism. Finally came the "Motazeles," or "Dissenters," who avoided the extremes of the other beliefs. They differed in their own sects on minor details, but agreed in not recognizing in

God attributes distinct from his essence; and thus avoided everything that seemed able to injure the dogma of the unity of God. "They accorded to man free will in his actions, and maintained the justice of God, in that man chose for himself good or evil; therefore the merit, or demerit, was his alone. They said: All that is necessary for salvation is within the province of reason, and could have been acquired by its sole light before the existence of law or before revelation. It is thus an obligation upon man so to acqure it in all times and all places."

"This heresy, in opposing orthodoxy and all other heresies, had especial need of dialectics, and its advocates became well skilled in their use. It is probable that the contact of the Arabs with the Christians of Syria and Chaldæa, where Greek literature was cultivated, had introduced the language of philosophy, as well as assisted in the origin of the schisms." *

With the downfall of the Omayyad dynasty in 750 began the reign of the Abassides. A few years later Baghdad was founded, the capital of the Empire of the Caliphs. While Western Europe was in the deepest sleep of the Dark Ages, Al Massur, the builder of Baghdad, drew around him men learned in the knowledge of Greek literature. His successors, particularly Al Mamoun, made noble efforts to disseminate the learning of ancient times among the

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*Solomon Munk: Philosophie Juive et Arabe.

Moslems through the translations from the Syriac. In this manner they became familiar with the works of Aristotle, whose empiric teaching accorded much better with their needs than the idealism of Plato. They valued, at first especially, the practical utility of Aristotle's works on medicine (in which their own knowledge soon far exceeded that of Europe), on physics, and on astronomy. The latter two were so closely allied to philosophy that they soon felt its need, especially in the use of dialectics. Thus, while the schools opened by Charlemagne in his empire were struggling over the primers of the language, or at the utmost with the grammar as then taught, the schools of Baghdad were in possession and in familiar use of many of the works of Aristotle that did not reach Europe until the latter part of the twelfth century. Many of these books, as well as numbers of other ancient writings, have only reached us through their preservation in the Arabic version. The Arabic philosophy was thus almost exclusively the peripatetic, more or less tinctured by neoplatonism. Thus Avicenna (Ibn-Sina, b. 980) sought to reconcile the existence of the Absolute—the Unapproachable—with the sublunary world by establishing a chain of intermediate spheres or links by which the pure energy was communicated to all the varieties of matter.*

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* S. Munk: Philosophie Juive et Arabe. P. 445.

The names of Al Kendi, Al Farabi, Avicenna, Avempace, became well known to all the scholastics of Europe, while Averrhoes (Ibn Roschd., b. 1126) was recognized as the most learned among the Mohammedans, and the profoundest of all commentators on the works of Aristotle. His medical knowledge was equally valued. As happens too often to original thinkers, he suffered much from the Orthodox believers; the Mussulman authorities accused him of holding opinions that were not orthodox, and of preaching philosophy that was detrimental to Mohammedanism. He was insulted in Cordova, his native town, and obliged to live in the suburbs. Later in life he was taken again into favor by the Caliph Almansur and called to the court at Morocco, where he soon afterwards died, aged seventy-two years. His philosophy, like that of Avicenna, was partly neoplatonic. He believed in the intermediate spheres and in the two intellects—the one active, the other passive—the hylic. The active one is an emanation of the Universal Intellect; the passive, of the receptive intellect. By the conjunction finally of the two, all that is personal in man, the receptive as well as the active intellect, will efface itself by uniting with God, the only veritable Being who is of an absolute unity. Man obtains from this conjunction of intellects nothing beyond this life. The general ideas which emanate from the universal intelligence are imperishable for all humanity; but nothing remains of the individual receptive intellect.* These ideas, which contain pantheistic principles, were violently opposed in the Latin schools by Albertus Magnus, St. Thomas Aquinas, and later by Duns Scotus. The later half of the thirteenth century was a battlefield in which the doctrines of St. Thomas Aquinas remained the conquerors. After Averrhoes no other Arabian philosophers became prominent in Europe.

THE JEWISH PHILOSOPHY.

The learned Orientalist, Solomon Munk (1802–1857), remarks: "The Jews, either as a nation or as a religious society, played only a secondary part in the history of philosophy; it was not their mission. It is incontestable, however, that they shared with the Arabs the merits of having preserved and propagated philosophical science during the ages of barbarism, and of having, for a certain time, exerted a civilizing influence on the European world." † "To know God and to make Him known to the world was the mission given to the Jewish people; but it was by the inspiration of faith, by a spontaneous revelation, that their people were led to God. It was by addressing themselves to the heart of man, to his sentiment of morality, and to his imagination, that the ancient Hebrews sought to cherish and to propagate the belief in the one Being—the Creator of all things. The existence of God, the spirituality of the soul, the knowledge of good and evil, were not with them the results of a series of syllogisms; they believed in God, the Creator, who had revealed Himself to their ancestors, and whose existence seemed to be above the reasoning of men; their moral faculties flowed naturally to the conviction—to the inward sentiment—of a just and good God." *

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* Solomon Munk: Philosophie Juive et Arabe. P. 445.

† La Philosophie chez les Juifs. P. 511.

It is impossible, nevertheless, to be in close contact with the speculative minds of others, without an effect, greater or less, on one's own mind. The doctrines held by the Alexandrine Hebrews, and especially the writings of Philo Judæus, show how strong this influence has been. The dialectics of Aristotle were called upon to defend the Montecallemin doctrines of the Karaite Hebrews (borrowed from those of the Arabian Montecallemin), the object of which was to establish the fundamentals of Judaism upon a philosophical basis.

The principal theses defended in the writings of the Montecallemin Karaites were: "The original matter has not been from all eternity; the world has

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* Ibid. P. 461.

been created, and therefore has a Creator; this Creator, who is God, has not either beginning or end; he is incorporeal, and is not enclosed in the limits of space. His science embraces all things; His life consists in the intelligence, and it is itself pure intelligence; He acts with free will, and His volition is conformable to His omniscience."

In physics the Montecallemin based their theory of the world on the existence of the atoms of Democritus, and consequently of intervening space, but they differed from Democritus, and from the Leibnitz theory of Monads, in supposing the atoms to be constantly created anew by the fiat of God, and existing at His pleasure only. They were without qualities and without extension; all bodies arise and perish by their aggregation and their separation. In this may be seen an approximation to the atomic theory of matter at the present day.

One of the earliest Jewish writers of the Middle Ages was Solomon Ibn Gebriol, the author of the "Source of Life." He was known to Europeans by the name of Avicebron, but generally supposed by them at the time to be an Arabian. His philosophical writings were in Arabic, though his poetic works, mostly hymns—highly valued by the Hebrews—were in their language. He was born at Malaga, Spain, about 1025. From the teachings of the

"Source of Life" in its Latin version the scholastics drew many of their notions of matter and form as taught by Aristotle, and modified by the Platonic, and Neo-Platonic ideas of its author. Between matter ("Hyle") and the form he placed the volition (La Volonte) which served as the intermediary agent. We find here the thought which dominated the Jewish theologians: that the *Word* of the creation indicated the volition of God, manifesting itself freely in the work of creation. "Dixitique Deus; Fiat lux. Et facta est lux." This volition of the *Logos* has thus been made into the first hypostasis of the Divinity, so as to avoid putting the First Substance, the Absolute—God—into immediate contact with the world. In fact though, volition as a divine attribute is inseparable from the Divinity, it is itself the divine essence. St. Thomas and Albertus Magnus considered Avicebron to be the first who gave *matter* as an attribute of the soul. This doctrine, the materiality of the soul, has been regarded as being to some extent the principal point in his system of philosophy. His doctrine verged closely on Pantheism, if not actually identified at times therewith.

Among all the Jewish philosophers none were so well known to the scholastics of the twelfth century, —or even to those of later times, who are conversant with the literature of the Middle Ages—as Maimonides, or as his own people knew him, Moses Ben Maimoun, born at Cordova 1135; d. 1204.

To the deepest knowledge of the religious literature of the Jews he added that of all the profane sciences then accessible to the Arabian world. Besides his other numerous works, his great work, "The Guide to the Erring" (Le Guide des Egarés), has powerfully contributed to spread among the Jews the study of the peripatetic philosophy. This work served as an intermediary between the Arabs and Christian Europe, and produced an incontestable influence on the scholastic philosophy. Its influence is felt to-day in the synagogue. It has survived peripatetism, but by its teachings the great geniuses of the modern Hebrews—Spinosa, Mendelssohn, Solomon Maimoun and many others were introduced to the Aristotelian philosophy. His views upon most questions were very similar to those of Averrhoes, and it was to the efforts of Maimonedes that the Arabian philosophy was made known to Christendom.

Christian scholasticism considered Maimonides one of the greatest thinkers that the world had seen for many centuries. Albertus Magnus and St. Thomas Aquinas were his disciples. He rejected all assimilation of God with his creatures. "One could say what God was not, but could not say what he was." He placed little importance upon the idea of a Providence. "It acts only through the intermediation of the reason. It does not trouble itself about the individual. Its thought is only for the preservation of the genus and species." He admitted the doctrine of Free Will, and recognized the influence of acquired habits and desires, which it was important should be satisfied in a suitable and proper manner. He formally condemned asceticism and a contemplative life as hostile to the development of the human race and to the fulfillment of its legitimate needs.*

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* Larousse. T. 10, p. 949.

CHAPTER II

FROM THE BIRTH OF THE SCHOLASTIC PHILOSOPHY TO THE DEATH OF ROGER BACON.

> "If that I did not know philosophy
> To be of all our vanities the motliest—
> The merest word that ever fool'd the ear
> From out the Schoolman's jargon—I should deem
> The golden secret, the sought "Kalon," found
> And seated in my soul." *

Aided by the Arabian and Hebrew learning, thus gradually came into being the system known as the Scholastic Philosophy: for many centuries the only form of erudition in Christian Europe. The sole mode of instruction was in the schools in which the teaching, by the "Schoolmen," as they were called, was entirely oral. Few or no books were accessible to the pupils, and for a long time few or none of them could read. The clerks, or those who could read and write,—the clericus—were the monks and ecclesiastics only. For many years the instruction was confined to the "trivium" of the liberal arts, grammar, rhetoric and logic. It was necessary before all that

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* Byron's Manfred. Act III., 1.

men should know the use of words before they could rise to the advancement of thoughts. The classical writers were long forbidden to be read, but Gerbert about 980 explained the works of Virgil, Horace, and of some others, to his pupils.

The study of the works of Aristotle, of which a few very imperfect copies had been preserved in the various monasteries, furnished a system of dialectics and the proper use of the syllogism that has practically remained without improvement almost to our day. His philosophy, viewed at first with disapproval, was later tolerated by the church, and finally adopted and fiercely defended by most of the Schoolmen in their disputes with the idealistic platonists. These disputes occupied the thoughts and the time of learned men until the downfall of scholasticism.

Aristotle possessed one of the greatest intellects that ever existed. A genius that has illuminated the human race; he seems to have ignored nothing that it was possible for the ancients to have known, and transmitted to us all the science of his epoque, whether derived from his predecessors, his contemporaries or through his own labors. Unlike his preceptor, Plato, he attached the highest importance to the experience of the senses. He distinguished with perfect clearness between deductive and inductive reasoning; but, notwithstanding his preference for the result of direct observation rather than theories, for him, as for Plato, the science par excellence was that of the *first principle*—the reason of things—and the syllogism the proper form thereof. Few, if any, attempts at experimental investigation are disclosed in his writings. In his day such attempts were thought discreditable, and indeed were so considered by most men until the dawn of the practical use of the inductive philosophy overthrew that of the peripatetic teachings.*

It has been stated that the philosophies of the ancients were not only philosophies but the religions of their advocates. They professed not only to teach the causes of existence and the nature of things, but deduced therefrom the principles that should guide men through life; that should influence their morality, and show them the hope, or the futility of hoping, for a future life. Philosophy in entering into scholasticism divorced itself absolutely from this religious element. The dogmas of Christianity in crystallizing ultimately into the rigid form of orthodox catholicism neither required nor permitted any accessions from philosophy, ancient or modern. The dogmas of the church, the nature of God, and the relations to each other of the several persons of the trinity, and of God to man, were questions strictly reserved to theology. If philosophers touched upon them otherwise than as the church prescribed, they became heretical and were punished as such. Ethics and morality were under the same jurisdiction, and needed no extraneous advice. The metaphysics of Aristotle, and later of Plato, in their association with theology were restricted to the consideration of the abstract nature of being: that all substances consisted of the Form—the ideal or spiritual existence—united with a gross, inert Matter, in itself devoid of all properties whatever. The doctrines of the nature of the Universals; the question whether all things existed in the abstract or in the individual; whether man, for instance, had an abstract or real being, not merely a verbal one, as apart from any individual man, was the subject matter of endless argument and fierce dispute, far beyond even the last days of Scholasticism.

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* Larousse.

According to Plato, Socrates says: "He is the wisest of men who, like Socrates, knows well that he is in truth worthless, so far as wisdom is concerned. (Apology, C. 9.) The really disgraceful ignorance is to think that you know what you really do not know." (Apology, C. 17.) Modern science teaches us the same lesson. We think we have learned much. We have gathered many facts regarding phenomena, but the more learning we have the more conscious we become that of absolute knowledge we have nothing!

It is only when we attempt to define accurately the ultimate nature of anything that we soon arrive at that borderland beyond which we cannot advance, even in thought. If we attempt to frame an idea in words they fail us, or we repeat in other words that which was said at first. It is as impossible for us to conceive that *space* is limited as it is to conceive its negative—that it is unlimited. If limited, what lies beyond? If unlimited, how can it extend forever and forever? As Herbert Spencer says: "We find ourselves totally unable to form any mental image of unbounded space, and yet totally unable to imagine bounds beyond which there is no space." So it is with time, and so with motion. Apparently clear and evident when vaguely considered, they melt into the incomprehensible when we try "to understand their essential nature, and bring us to alternate impossibilities of thought." So it is with matter. From the time of Plato and Aristotle it has been the battle-field of metaphysicians, and in mediæval times of the scholastic philosophers. Plato believed in the original co-existence of the two principles—one, the formless Matter; the other the Form or the *Spirit*, the artisan of all substance. Matter was without form and void, existing only in potency, "for in the beginning, before the generation of the compound, matter and form existed only in their causes, for nothing proceeds from nothing;" but it was matter which furnished the subsistent in each compound; but *form* gave the life or the existent. In this view "*form*" was the *vis creatrix*, being the IDEA, without which real existence was not. "Before the thing or substance the pure, simple *idea* thereof existed, in which idea nothing ever alters, nothing ever changes. The substance or the *things* are, however, the alliance of matter with *representative* forms, which are to the ideas as more or less imperfect copies are to their models, but which are never permanent in their condition, since they belong to another class of beings.* These views regarding the form and idea, held consciously or unconsciously, still lie at the basis of much of the metaphysical thought of the present day.

Among the Schoolmen for more than six centuries the main subjects that occupied their minds and their pens were the questions that grew out of these theories. What were the natures and the relations to each other of the *Universals*, of the *Genus*, of the *Species* and of the *Individuals?* These were the questions propounded in the third century by Porphyry in his introduction to the Categories of Aristotle, and translated by Boethius in the beginning of the sixth century for the Latin world. Until the fifteenth century, and even later, nearly all learned men worried and fought over these intangible riddles.

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* Avant les chosen sont les idees, pure, simple dont rien ne s'altere, dont rien ne se change jamais. Dont les choses sont les copies plus ou moins imparfait de ces idees, qui ne demeurant jamais dans le meme etat, appartiennent a une autre serie d'etres.

Philosophie Scho., T. 1., P. 69. Compare also Plato's Phædo, Sec. 62, et seq. H. Cary's Trans.

The words genus and species were collective terms, embracing all things of a like nature. Thus the genus "Animal" embraced not individual animals, but all animals. The species, man, horse, meant not an individual man or horse, but all men, all horses, etc..

Plato and Aristotle differed in their ultimate ideas even more than in their mode of expression. Plato held that the Universals, the Genus and the Species existed ideally, but nevertheless in reality, necessarily before the substances, as principles of their generation, and enjoyed as such a proper and permanent existence, whilst the individual (thing or substance) submitted to the law of movement, or change, and had nothing actual, fixed, or stable in itself; it was only a mere appearance of its being.

Aristotle, on the contrary, not holding existing things in the contempt that Plato did, makes with regard to the Genus, the Species and the Universals, properly so called, the following explicit declaration: "The man, the horse, *all* the Universals reside in the *individual.* The substance is not *some thing* or a part of the universal: it is a totality—a compound of *such* form and of *such* matter. No universal has an existence isolated from the individual being; nothing of that which applies to *all* beings (or generalities) is substance, and there is no substance composed of substance.* The undefined is an existence in potency, and not in act. The *definition* is the *expression* of the *essence*, and the *essence* is only found in the substance; at least, it is found above all, first of all; in fine, *absolutely*, in the substance." †

Plato placed the Universal in an ideal region of its own, and professed that from this superior region, anterior to phenomenal nature, the principles were communicated to things (substances) that determined their manner of being. Aristotle also recognized that the individual thing could only be defined or named through the universal; but when he sought beyond the individual for the universal, which is the foundation of all definition, he could find it nowhere but in the human understanding."

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* "L' homme, l'cheval, tous les Universaux resident dans les individus, la substance n'est pas quelquechose d'universel; c'est un ensemble, un compose de telle forme et de telle matiere (*a*) Rien d'universal n' a une existence isolee des etres particuliers Rien de qui s'applique a tous les etres n'est substance, et il n, ya aucune substance composes de substance." (*b*) The latter clause in the sentence is to disavow the notion that matter as an universal was composed of an assembly of all individual subsistents.

Idem. P. 81. (*a*) Metaphysics VII., 10. (Aristotle.)

(*b*) VII-16, Trad. de MM. Pierron et Zevort.

† Aristotle had previously established that Matter (distinguished from such or such matter) was an universal, and adds that, being an universal, Matter was not a substance. He had thus expressed himself: "L'indertimine, c'est l'etre en puissance et non en act. Il est evident que la definition est l'expression de l'essence, et que l'essence ne se trouve que dans les substances, ou du moins qu' elle se trouve surtout, et avant tout, absolutement enfin dans les substance.

(*a*) Philo. Scholas. T. 1, P. 82. Aristotle Metaphysics VII., 4.

(*b*) Ibid., IV. 4.

Upon these distinctions arose the conflicting doctrines of the Realists and of the Nominalists. The one holding that the quiddity or the abstract nature of the substance existed really only in the Form; *i. e.*, in the idea or thought of the Creative Spirit. The other, that the substances—*i. e.*, the combination of the form with matter—was the only quiddity; the individual thing was the only reality, all else existing only potentially. These different views have descended to our times, and have given rise to endless discussion among metaphysicians.

The philosophy of the Middle Ages, the learning, thought and writings of Gerbert, of John Scott Erigena, of Roscelin, of Abelard, of Duns Scotus, and largely even of Albertus Magnus, were little else than the discussions from varied points of view of these theories and of the nature of the Universal in regard to the three questions of Porphyry.

Albertus Magnus states that the nature of the Universals might be considered in three ways: First, "Universale ante rem" is single and unchangeable, the nature, which was the name and cause of existence; second, "Universale post rem," as existing in the human intellect; third, "Universale in re," having this or that as its subject; in other words, the *substance.** Having thus defined what the substance was in reality, they left it without further study. Such postulates constituted the "physics" of the Scholastics, but to us are metaphysics only.

The downfall of Scholasticism came with the introduction of printing; but many of the doctrines of its philosophy long survived it. To study the nature of material things by actual handling and experimental investigation was considered unworthy and degrading. The conviction that whatever *was* existed in its essence in the *mind* had the corresponding belief that what existed in *thought* must have *reality;* and an a-priori conviction, therefore, had a better foundation than an empirical demonstration; for the former, if logically deduced from accepted premises, must be-correct; whilst appearances were deceitful and experience known to be full of error.

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* Il y a trois maniere de considerer l'universel: (premierement il est pris en lui-meme c'est-a-dire comme etant cette nature simple et invariable qui donne la raison et le nom de l'etre: (Universal ante rem); Secondment, comme etant dans l'intellect: (Universale post rem:) troisiement comme ayant pour sujet, ceci ou cela (Universale in re.) Histoire de la philo.; Scholas., T. 2, P. 232.

Haureau states: "The ancients recognized three kinds of forms: 1st, the forms which are *before* the things, and which are the models of all existing things; 2d, the forms which are *in* the things, and which communicate to them that which is their manner of being—'universelles' in the sense that they belong to many; 'individuelles' in the sense that they particularize themselves in the bosom of things of limited number; 3d, the forms that are *after* things; that is, the forms which transmitted to human intelligence by the divine, or which recurred without the concurrence of the divine, hold their universality from one or by the other.

The first of these forms are the principles of things. The second are the essences of things. The third are the marks of things. Ibid, T. 2, P. 233.

Albertus,† though an Aristotelian, was eclectic in his treatment of the realistic and nominalistic views. The reader is referred to an exhaustive discussion thereon. See Albert Le Grand, T. 2, P. 215–307. Haureau, Scho. Philo.

† De proedicabilibus. Tract 11, c. 111

It was not until the advanced days of Scholasticism that a Franciscan monk, **ROGER BACON**, astonished, and for the most part disgusted, the learned world by his heterodox teaching, that any effort really to advance scientific knowledge was made in the schools. "About 1248, Bacon, having left Oxford, came to Paris to finish his studies and to be examined for his doctorate. The University of Paris then had a crowd of highly applauded masters, well worthy of their great renown, but Bacon was not satisfied with any of them. They did not know, he said, the elements, nor even the object, of true science. These false savants were skillful in composing and distributing a lot of chimerical beings, but had never taken care to observe any *real* being. They made a profession of teaching physics, but one and the other, whatever might be their sect, deceived the people with the same effrontery: all teaching under the name of physics, only a frivolous metaphysics."

After finishing his studies in Paris, Roger Bacon returned to Oxford in 1250, where he was received with great applause. But Bacon was born, unfortunately for him, with a mind and ideas more than three centuries in advance of those who were in power over him. About seven years later, as the natural result of his teaching doctrines differing so widely from those commonly held at his time, his lectures, wherein he urged experimental investigation, were interdicted, and he was ordered to Paris, where he was kept for ten years, virtually in prison and prohibited from lecturing or writing for publication. The appointment of Pope Clement IV., who had known Bacon, and the order from him to write and forward him a treatise on the sciences, soon after gave Bacon his liberty. In a work he wrote in 1270 Bacon made a virulent attack upon the ignorance and vices of the monks and clergy. Such censures were then considered blasphemies, for which he was punished by fourteen years' actual imprisonment and his books condemned. When set free in 1292 (by the death of Nicholas IV.) he was nearly an octogenarian, and could no longer inspire fear. Even the date of his death is unknown. For more than two centuries longer, scholasticism slept in peace.

When we consider the number of men, learned in letters, and having all the means time and opportunity in their monastic retreats during nearly a thousand years for the true study of nature and of the works of God, it seems almost incomprehensible that absolutely nothing was done by them. The thoughts of the wisest men were paralyzed by the conviction that when God said, "Let us make man in our image and likeness," * the mind of man was the subject of the likeness, even more so than the body; therefore, to study the intellect and its faculties was to learn to know the Creative Reason, the Intellectus Agens, of Aristotle: truly, if knowable, the noblest study for mankind! But the lapse of 2300 years from the days of early Greece had taught men nothing! To such minds Matter, as presented to the senses, offered only that which was base and degrading. With most men still lingered vestiges of the Gnostic belief that, for its bare existence even, a Demiurgos was needed, since it was insulting to the Absolute, the Unconditioned Being to imagine Him to come into contact with the material of this impure earth, even by creating it.

If the thought which men have spent upon the ultimate nature of the universals and of their relation to the Absolute had been devoted to observing the tangible world around them; if they had studied the

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* "Faciemus hominum ad imaginem et similitudinem nostram." Vulgate. Gen. 1, 27.

visible works of God and the laws that govern their action, instead of the fond conceits of their own minds as to the ultimate nature of the Unknowable, in how different a world we might now be living!

CHAPTER III

BELIEF IN ASTROLOGY AND ALCHEMY — THEIR INDIRECT BENEFIT TO MANKIND—THE BELIEF IN WITCHCRAFT.

"Du wirst auf die Sternen-stunde warten
Bis dir die irdische entflieht! glaub mir
In deiner Brust sind deiner Schicksals Sterne.
Vertrauen zu dir selbst. Entschlossenheit
Ist deine Venus! Der Maleficus,
Der einzige der dir Schadet, ist der Zweifel." *

It has often happened in the individual experiences of men that their mistakes, their failures, and sometimes even their superstitious follies, have led to success in the purposes they had in view, when their wisest thoughts, best laid plans and well constructed efforts had proved vain and abortive. The history of the Middle Ages shows the same results to have attended the growth of knowledge and the progress of science, All that philosophy could teach and academical learning show, after hundreds of years devoted to their study, was emptiness and vanity. We now know

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* Schiller: Die Piccolomini 2-Aufzug. 6-Auftritt.

that the teachers of true knowledge had often been the covetous, the credulous and the charlatan.

Two pseudo sciences, astrology and alchemy, born in delusions, nourished and raised chiefly by fraud and superstition, have each given birth in their old age to offspring respectively the wonder and the pride of mankind! The elder, astrology, born on the plains of Chaldea more than 10,000 years ago, was at an early date the parent of the worship of the planets, of which the sun was considered as being one, and whose worship continues in some lands to the present day. Astrology was looked upon as the arbiter, disposer and revealer of man's destiny, and was accepted as such by many of the greatest minds as late as the seventeenth century. It was believed in by Albertus Magnus, Thomas Aquinas, Charles the Fifth, Tycho-Brahe and Kepler. It was the daily guide of Wallenstein; even Napoleon had faith in the stars. At last, in the seventeenth century, when finally forsaken by nearly all, it left a daughter—Astronomy—crowned with honor and glory, placed at the summit of human achievement.

Alchemy, the younger pseudo science, had a more honorable origin. Born, as its name may seem to indicate (Al-Khemi), in Egypt; claiming its birth from Trismegistus and the Hermetic books, and coming from Arabia to Europe, the knowledge that it brought was real, embracing all that time and experience had given it in the past centuries. Many of the Arts among the Orientals had reached an advanced state. Their physicians were learned—had much surgical knowledge and an extensive materia medica: The armorer's metal work, enamels, and jewelry showed skilful and practiced artisans. Handling thus metals, their alloys and other minerals, their labors soon led them to the adoption of the Scholastic or Aristotelian theories of Matter and Form; that is, that the *Matter* of all the metals and of all things being one and the same, it followed that one metal could be changed into another one if the suitable means of varying the *Form* was discovered. The resemblance that many of the sulphides of the metals bore to the metals themselves led to the belief that all the metals proper were compounds of sulphur and mercury; the latter, being the most volatile, silverlike, and the only metal liquid at ordinary temperature, appeared naturally to be the proper vehicle for the formation of gold and silver—the noblest of metals—if only perfect sulphur and perfect mercury could be found. If the conversion of one metal might thus be accomplished, the conversion of other things would doubtless soon follow.

The pursuit of the object thus sought for, was called the search for the Philosopher's Stone. The reasoning that caused the quest was logical and the desired conclusion most probable, if only the premises assumed were correct. Unfortunately they were not so; but, like the mirage in the desert, the hoped for result seemed ever near, but was never reached. It was believed that an agent, if ever found, thus powerful over the refractory metals, must likewise be so over the human body. Its zealous pursuers misunderstood or took in a literal sense, the enigmatical phrases and recipes of the masters of the art; thus the Philosopher's Stone or "Powder of Projection," as it was often called, became also the Elixir of life to be sought for as the cure for all the ills that affected the body, and the prolonger indefinitely of human existence.

Introduced into Constantinople as early as the fourth century, Alchemy was practiced there extensively. After the establishment of Mohammedanism it was carried by the Arab, Geber, to a high degree of perfection. Offering to its adherents the greatest prizes this world could give, and quite consistent in its theories and principles with the knowledge of the time, it drew to itself men of all degrees, from the college, the cloister and the throne. Beside the Arabs—Geber, Avicennes, Averrhoes—the Christians, Roger Bacon, Albertus Magnus, Raymond Lully, Paracelsus—and even Henry VI. of England, were among its disciples. Rudolph II., Emperor of Germany, devoted much of his time to its practice, and employed the celebrated Tycho-Brahe in this labor and in astrological work. Lord Bacon, Spinoza, Leibnitz and Sir Isaac Newton all believed in the transmutation of metals through the Philosopher's Stone. The minds of all men were so imbued with the conviction that a-priori reasoning was the only gateway to knowledge that the valuable results of experiment were to a great extent lost. The conception that the Platonic, idealistic doctrine of the Formative Spirit alone lent to matter its tangible existence gave birth to an endless number of imaginary aerial beings that exercised a controlling influence over all their work. Every metal stood under the mysterious influence of one of the planets. It became therefore necessary in their researches that the astronomical, or rather the astrological, state of the heavens should be observed, as it would be an all-important factor in the hoped for result. Each planet and each metal held control over certain portions of the human body. The almanacs for the people long held, and a few still hold, a chart in which the human body is apportioned among the ruling planets and the signs of the zodiac. This relation between them and the nature of man must also enter into consideration, since the planets or certain stars had dominion over health, fortune, riches, birth, life, death, etc., as the stars might enter, or rule over, one or the other of the twelve houses into which the heavens were divided.

The incidental benefits which these labors, vain in their original purpose, gave to the world, and the discoveries made thereby have been of incalculable value. Almost all that was known in chemistry, in medicine and metallurgy, as late as the middle of the eighteenth century, has been its legacy. But the facts collected were necessarily disconnected, of conflicting and uncertain value; a heterogeneous mass of recipes, products and compounds, into which little or no attempt had been made to introduce systematic classification or scientific order.

Another cause, more potent still, held back with iron hand the advance of science; this was the belief of the church and of the people in witchcraft and in the demonic powers that Alchemy could invoke. From what has been said of the Platonic theories of the constitution of the substance—*i. e.*, the union of the inform Matter without body, shape or substance, with the creative spirit or the essence of the Form—it is evident that the *substance*, with its accident or peculiar qualities, depended upon the said Form, essence or spirit. The Church asserted that this spirit was the Divine creative Spirit; and, having thus said, to question further was unwise, if not impious.

The students of Alchemy were not always so very docile. Without discussing the abstract nature of the Divine Spirit, many believed that other spirits existed, and that each controlled certain of the four elements: the air, fire, water and the earth, of which all things were made. Most of these elementary Spirits were thought to be negative in their character, neither good nor evil. Others, though, were unquestionably evil, but could be induced to render aid to one person in order to injure another, or give a present and immediate help, to be paid for in a distant future. Many formula for incantation and conjuration existed in books of Magic, and were taught by the professors of the art as being an indispensable aid. The Church did not question the verity of these Spiritual Existences as much even as did many of the Alchemists, but viewed them all as beings from Hell, and that they were Devils, or the children of the Devil.

It was natural, therefore, that the Church should look with disfavor upon the practice of the art; but many men of high positions within its fold, as we have seen, were active therein, and the temporal fortune of the Church might even itself profit through the Philosopher's Stone. Its study and practice, therefore, were not exactly prohibited, yet the followers of the Black Art, as it was called, were closely watched and quickly called to account and punished for any infraction of dogma or of discipline that arose therefrom. So long as men confined themselves to the legitimate work of their laboratories—the quest for the power of transmutation—they were not disturbed; but if they sought beyond or attempted to question the truth of the teaching of the orthodox Natura Naturata, the fate of Roger Bacon and of Galileo, if not that of Giordano Bruno, awaited them.

The general belief in the agency and power of these master and ministering spirits of the unseen world led to the dread delusion of Witchcraft, whose horrors spread over Europe the more widely as the practice of Alchemy became more general, and with it died as the world grew wiser. The history of its cruel persecution, of the innocent lives that passed away in a fiery death, and of the fearful superstition, common alike to the magistrates, to the priests of the Roman and to the ministers of the Reformed Churches, lie, fortunately for us, outside of our province, and needs not to be further here discussed.

To recapitulate: thus far as we have seen, the learning of the world, apart from theology and dialectics, principally consisted in studying, contrasting, or endeavoring to reconcile the more or less contradictory views of Plato and Aristotle. The so-called Physics of the latter were assumed to be true. The Ptolemaic system of the universe, in which the Earth was the centre around which all the planets and the stars revolved, was apparently the natural and proper place for God to become incarnate. It became identified with the true Catholic Faith, which none were allowed to question. The doctrine that man was created pure, innocent and wise; that he had since become degraded, and that to turn to the learning of the past was to draw from the fountain of pure wisdom was not only the teaching of the Church, but the inborn conviction of nearly all men. Holding to these opinions the world could not advance. A new revelation was needed, and it was soon to open.

CHAPTER IV

THE PUBLICATION OF THE TRUE PLANETARY SYSTEM BY COPERNICUS—IT ESCAPES FOR FIFTY YEARS THE NOTICE OF THE CHURCH.

> Sta Sol. Ne moveare. Sapere auso.
>
> * * * * * *
>
> La Pologne enfanta l'homme.
> Qui arreta le soleil et fit mouvoir la terre.*

NICHOLAS COPERNICUS was born Feb. 19, 1473, at Thorn, in Prussian Poland. Died May 24, 1543. His father, who died young, bore the same Christian name. His mother was Barbara Watzelrod, sister of the Bishop of Warnic, or Emerland, in Poland, who educated him. At the age of 18 he was sent to the University of Cracow, where he studied Latin, Greek, and particularly Mathematics. Two years later he returned to Thorn with the intention of taking orders, but in 1495 he repaired to Padua, where, in its University and in that of Bologna, he achieved so great a reputation that he was called to Rome, when 27 years old, to the professorship of mathematics. After a short time spent in Thorn he returned to Italy, but in 1503 left for Cracow, where he was made a priest. He settled finally in 1510 at Frauenberg on the shores of the Baltic. Here he built an observatory and perfected his astronomical labors. Copernicus had studied all the works on astronomy that had come down from antiquity. He was probably acquainted with those of Nicholas of Cusa, who had preceded him in his theory nearly two generations. Cusa's works were published in Paris in 1514. Copernicus saw that the system described by Apollonius of Perge —the author of Epicycles—that placed the sun in the centre of the planets' orbits, but caused it to move like the moon around the earth (the system afterwards adopted by Tycho-Brahe), was much simpler than the Ptolemaic, and explained better the movement of Venus and Mars; but it did not satisfy his own required conditions for the earth. He completed his new Astronomy about 1512, but from diffidence and distrust of himself, as well as from the fear of ridicule, it was not published to the world until 1543, at Nuremberg, when he was 70 years of age. This fear of ridicule was well founded, for there is nothing so sure of itself or so intolerant as ignorance.

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* From the monument to him in the church at Cracow. Translated from the Polish. Larousse.

As early as 1530, the report of his novel views had spread far and wide among the astronomers; but he still withheld his publications—varying and repeating his observations and testing his new theories by calculating their adaptation to explain the most difficult and complicated problems, such as the apparently retrograde motions of the planets, the procession of the equinoxes, etc. Finally, in 1543, his book appeared, "De Orbium Celestium Revolutionibus," in which the sun is placed at the centre of the system. Around it the planets revolved in their orbits, which he thought were perfect circles, of which planets the earth was one. It revolved on its axis, and around it its satellite, the moon. He dedicated his book to the Pope, Paul III., saying: "In order that they may not accuse me of fleeing from the judgment of enlightened people, and in order that the authority of your Holiness, if you approve this work, may preserve me from the virulence of calumny."

The first copy of his work was brought to him only when on his deathbed. He touched it, saw it, but his mind was then nearly gone. In a few hours he was dead.

The system of Copernicus was eagerly adopted by some of the most illustrious savants, but decried by many others. He could offer no other proofs of its truth than its simplicity, in opposition to the complexity of the Ptolemaic system. Since his day many proofs are present to us that did not exist in his time.

The telescope had not then been invented. The first direct proof of his theory was given when Galileo saw the disk of Venus, could distinguish the phases of Venus and of Mars, and determine the variation of their apparent diameters as they changed their position in their orbits.

Copernicus, though founding a system of Astronomy in direct opposition to that taught by the philosophy of the Catholic faith, was opposed to the Reformation that Luther was effecting in Germany. It is possible that the fact of his non-participation in the religious movement against the Church may have permitted him to carry out his labors in peace and quiet to their completion, for the novelty of his theories had attracted much attention long before their open publication. His work, being addressed to astronomers only, devoid of all reflection upon the influence that it might exert over the dogmatic teachings of the Church, published at the expense of a Cardinal and dedicated to the Pope, escaped for a long time the "Index Expurgatorus." The Theories of Kepler, contradicted or confirmed as they individually might be through his persevering observations and calculations, resulted finally, in the establishment of his three well-known laws and their publications in 1608 and 1618, thus perfecting and confirming the Copernican system of Astronomy.

By this time the Church had awakened to its importance, and prohibited its teaching and that of Kepler.

CHAPTER V

GIORDANO BRUNO ADVOCATES THE COPERNICAN ASTRONOMY AND THE PLURALITY OF WORLDS—ARRESTED BY THE HOLY INQUISITION—IMPRISONED FOR SEVEN YEARS, THEN BURNED ALIVE—HIS VIEWS AND DOCTRINES.

THE promoters and advocates of the true study of nature and of the advance of knowledge had kept thus far strictly within the lines of religious dogma as accepted substantially both by the Church of Rome and by the Protestants. About the middle of the sixteenth century a man was born who attacked the foundation of orthodox belief, as well as those of the philosophy and physics on which both divisions of Faith rested. His teachings, though influencing and forming to a great degree the doctrines of Descartes, Spinoza and the other master minds of the seventeenth century, had remained but little known to the laity and the generality of readers until the latter half of this century, when the wider progress of science has brought his name prominently before the world. One of the great philosophers of the sixteenth century, if not the greatest—GIORDANO BRUNO—was born at Nola, near Naples, Italy, in 1548. As Huss was a Martyr to the Reformation, though preceding it, so Bruno was a still greater Martyr in advance of the Revolution in Philosophy; a greater Martyr, for he was unrecognized and misunderstood by all. None gave him honor in life, and he ended it as Huss did, and at least as courageously, in flames on the scaffold.

Little is known of the parentage and early days of Bruno. The exact date of his birth is unknown. He first appears when entering the order of the Dominicans at Naples in his 15th year. His education had been well cared for. To the mathematical and philosophical sciences of the day he added the studies of letters and theology, showing from his youth a happy memory, a facile conception and an ardent, enthusiastic spirit. The desire to increase the light given him was the cause of his entering the order, but the corrupt morals of his companions of the Cloister, and the difficulties beyond number that the dogmas of the Roman Church presented to his mind, soon disgusted him with his new condition. He abandoned his convent and his country and withdrew to Geneva about 1580. There he studied Calvinism, but, dissatisfied therewith, left Geneva after two years, passing by the way of Lyons and Toulouse to Paris, taking with him the proofs in printing of several works which he published there. Since his religious views did not permit him to speak from any pulpit, he had himself made "Professeur Extraordinaire" of Philosophy. He attacked violently the doctrines of Aristotle accepted then by most men. His own metaphysical doctrines were founded on the Platonic Philosophy, and leaned, as the latter did, towards Pantheism.

The disagreeable treatment that his opinions drew upon him caused him to pass over to England about 1583. He was kindly received by Queen Elizabeth, to whom he dedicated poems in which he compared her to Diana, and found united in her the beauty of Cleopatra and the genius of Semiramis. These praises of a heretic Queen were among the crimes he was charged with before the Inquisition. Sir Philip Sydney also befriended him, as many others did at Court. In London he published his famous book "Spaccio Della Bestia Trionfanti" (Expulsion of the Triumphant Beast), and several other books of the same nature. Among them was the "Cena delle Ceneri" (The Supper of Ash Wednesday), devoted to the exposition of the Copernican theory. In the same year (1584) appeared his two great metaphysical works, "Della Causa—Principio ed Uno" and "Del Infinito Universo e Mundi." In 1585 he returned to Paris for three months. In 1586 he went to Wittenberg, where he taught Philosophy until 1588. He then spent a short time successively in Prague, Brunswick, Helmstadt, and in 1590 was in Frankfort-on-the-Main. In 1591 the imprudent desire to revisit his native land led him at first to Switzerland and then in 1592 to Venice. After residing there seven or eight months he was denounced as a heretic by Zuane Mocenigo, who had invited Bruno there to instruct him, and was delivered by him into the hands of the Inquisition. He was arrested and shut up in the prisons of the Inquisition. Thence he was transferred, February 27, 1593, to Rome, where he languished for seven years in its dungeons. This detention is represented to us as a mercy that was extended to him to permit time for a retraction of his errors! Finally, on February 9, 1600, his sentence of death was read to him. He was convicted of being an apostate, a heretic, and one faithless to the vows of his orders. He was degraded and delivered to the Secular Arm. On February 17th he was conducted to the Campo di Fiori and burned alive at the stake. It is reported that when his condemnation was read to him he said to his judges: "This sentence, pronounced in the name of a God of Mercy, may cause to you, perhaps, more fear than it does to me."

It was not so much the heretical theistic doctrines of the unity of "All in One" that armed the fearful severity of the Inquisition against him, as it was the assertion that the Earth moved around the Sun—the same conviction that brought so much suffering to Galileo. Besides this, the open attack upon the Aristotelian Philosophy, the many expressions against the Monks and the prominent doctrines of the Church, added to the animosity of his judges. Bruno was urged to recant. Up to the last moment, it is said, he might have saved his life by a simple recantation. He disdained to do so, or to disown his convictions, and thrust the crucifix away when held before him as the emblem of repentance.

Bruno had no sympathizers to support or strengthen him. "No saintly halo, no echo of future renown was there, no admiring disciple kept his teaching, to rise in the future like a phœnix from his ashes. His contemporaries, almost without exception, called him a fanatic in life and in doctrine, thoughtless, unsteady, quarrelsome, rude to his opponents, headstrong, arrogant, obscure, confused in his doctrines and inclined to dissipation. It is not to be believed that a man who was inspired so strongly by the ideal—more ardently even than any other living man—could be thus wrongly constituted in his life. They did not understand his doctrine. The wisest and most honest of men are not wise and good enough to avoid deceiving themselves as to the life and character of a man. The obscurity that surrounded his life's history does not permit his formal justification. In his doctrines at least Bruno was not unsettled, obscure, confused or fanatic." *

Bruno, however, had not escaped the delusions of his age. He was a firm believer in the fantastic doctrines of Raymond Lully, by whose combination of logic, numerals and symbols it was thought the truths of Philosophy could be demonstrated. Bruno shared this belief with many of the Schoolmen of his age. He used it mainly as a system of Mnemonics. It was to instruct in this so-called Science that the patrician, Mocenigo, lured him into Venice with the already formed intention, it is said, of betraying him to the Inquisition.

The life and history of the career of the Cardinal, Nicholas of Cusa, born 1401, died 1464, had probably much influence on the doctrines of Bruno. The former, born of very humble origin, the son of a poor fisherman, rose to high dignity in the Church, and applied himself passionately to science. He adopted the Pythagorean System of the solar planetary bodies nearly one hundred years before Copernicus. Cusa proposed many doctrines at variance with the ortho-

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* J. Meyer. Grosses Kons. Lex.

dox teachings of the Church. He believed in the possibility of a perfect peace between Philosophy and Religion, and of a fusion of all religions into one—"Since they contained as their foundation the same truth, the same faith, the same God." His views, held modestly but firmly, seem to have given no offence.

At the end of the 16th century Bruno found a different atmosphere around the Church. The reaction against the Reformation was at its height. The theories of Copernicus, of Keplar and of others alarmed the Church; they threatened the stability of the foundation of all Christian teaching, and as Bruno had spread his learning and his books over all Europe, Protestant and Catholic, so was his punishment to be sure and inevitable; a lesson to the world. It seems, though, that no presentiment of his fate was felt by him on entering Italy. He was so well convinced that his ideas of Philosophy and Religion were right, and that in the latter he was not heretical, that he felt no fear. When he had spent years in prison he was still unchanged, and was willing to die rather than be false to his convictions and recant, as Galileo did. The Metaphysics, Religion and Philosophy of Bruno may be told in his own words:

"It is recognized as an universal truth that every compound or thing divisible has for its foundation something that is not compounded and that is indivisible. The understanding of Man has striven unceasingly to seek out this unity, and will never cease to seek and strive for it until he can find it in the nature of the substance, or can at least present a clear conception thereof to his imagination. This Unity can only be in God! Let all that have breath rise up to the praise of the Most High and Mighty One, who alone is the Good and the Truth: to the praise of the Infinite Being, who is the Cause and the Principle—The One and the All. God is infinite in infinity: everywhere in all. Not above, but everywhere present: as existence is not outside of the existent, as the natural is not above or beyond nature, as Goodness is not other than the Good. God is the Single Being, with whom there is no combination; with whom there can be no difference. Existence, power, action and will are, with Him, one. His will is necessary—necessity itself. He is like only unto Himself, and ever the same. Freedom and necessity are with Him one. What God makes he cannot make otherwise than as He makes it. He acts from necessity; for the Infinite Power, if limited neither by itself nor through anything else, acts through the necessity of its being. Therefore what God creates must be without an end, for he works according to the necessity of His being.

"The All is one and infinite. But if the Universe is infinite, it is also not removable. It cannot change its place, for outside of it there is no place. It is not engendered, for all existence is its own existence. It cannot pass away, for there is nothing into which it could pass. It can neither increase nor decrease; for, being itself Infinite, in which no relative proportions apply, still less can it be added to or taken from. It is subject to no change, neither from outward nor inward, for *out* of it nothing is, nor from *within*, because it is all that is, and that can be, at once and at the same time.

"We cannot elevate our minds to the conception of the Most High, the knowledge of whom lies beyond the limits of the human understanding; but we can to that intelligence that forms the soul of the world, is capable of all, accomplishes all, is all, and from the endless number of things therein, which is of it and in it, forms one being. To know this Unity is the object of the investigation of nature and of all Philosophy.

"There exists, or may exist, an infinite number of worlds like unto ours, since space is infinite. These worlds cannot interfere with each other, for in space the centre is everywhere. The universe has no form, for that which is infinite can have none. The Evil and the Good, the useful and the hurtful, the just and the unjust, are nothing in themselves; they exist only by comparison; in fact, the infinite power of God would have no place if there existed simultaneously an infinite principle of Evil. The Atoms * are the foundation and basis of all things; but they are put in motion by the spirit of God—the soul of the world. †

"The Sun—the Father of life—is the centre of our world, but the centre of the Universe is in all things . . . There are as many centres as there are worlds and stars, and these in number are infinite. The Earth moves; it turns on its own axis and it moves around the sun . . . There are innumerable worlds like ours, throned and spaced amidst the Ether and pursuing a course in heaven like unto ours. The suns are inhabited as well as the surrounding earths. It is not reasonable to believe that any part of the Universe is without a soul, life, sensation and organic structure; and it is as foolish to believe that there are no beings, nor minds, nor possibilities of thought beyond the objects of our own senses . . . From this infinite all, full of beauty and splendor, from the vast worlds which circle above us to the sparkling dew of stars beyond, the conclusion is drawn that there are an infinity of creatures; a vast multi-

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* Of Lucretius.

† J. Meyer—Kons'n Lex'n. Edition 1843, 52 vols., O.

tude, which each in its degree mirrors forth the splendor, wisdom and excellence of the Divine Being."[*] This is what the Church decries as Pantheism!

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[*] Life of Bruno by I. Frith, p. 43, *et seq.*

CHAPTER VI

EXTENSION OF THE STUDY OF PHILOSOPHY AMONG THE LAITY—THE LIFE AND WRITINGS OF DESCARTES—OPPOSITION TO THE ARISTOTELIAN DOGMAS AND TO ALL AUTHORITY THAT COULD CONTROL THOUGHT AND LEARNING.

During the greater part of the sixteenth century the learning that before then had practically been confined to the religious orders had by that time thoroughly penetrated the higher classes of the laity. Men of rank, of wealth and of leisure became also often men of learning. Belles-Lettres and poetry principally interested them; but an ever-increasing number devoted their time to the study of Philosophy

Born under happier influences than the ill-fated Bruno, **Rene Descartes**, the son of a noble family, began his life in Touraine, France, March 31, 1596. Educated by the Jesuits, he early showed, though delicate in health, a passionate love for study. On arriving at his philosophical course he soon found the emptiness of so-called science, as then taught;

but he was strongly attracted by mathematics, which he was destined to greatly improve. His biographer, Biot, states:

"His first endeavor, on leaving school, was to erase from his understanding, as far as possible, all that was uncertain in its nature, and thenceforward to admit only that which was capable of being proved by reason and demonstration. He thus invented that system of doubt and of examination which has since been the first principle of all positive science. We do not now appreciate the value of such an effort; for we have grown up under its teaching, so that it seems reasonable and natural. But at the time of Descartes the Aristotelian Philosophy ruled despotically over all minds. It was considered in the Colleges the necessary support of all religion. To doubt Aristotle was not only a novelty, but a crime. What strength of mind must this young man of nineteen have possessed to have hoped to reform the judgment of all. It is not less astonishing that Descartes appears at that time to have already made his most brilliant mathematical discoveries.

"He thought it was not yet the time to publish his new ideas. He determined to enter the Army, which would give him the opportunity to travel and to see the world. He served as a Volunteer in the troops of Holland and of the Duke of Bavaria.

He continued his mathematical and metaphysical speculations during his camp life for some years, until finally the reverses that the army met with and that he witnessed in Hungary caused him to relinquish his military position. After this he traveled for some time in France, Holland, Switzerland, the Tyrol, Italy, Venice and Rome. He never met Galileo, nor did he ever appreciate his great discoveries, showing that, admirable as Descartes was in Geometry, he was ignorant of the true principles of that method of observation which alone could advance the knowledge of Physics. In 1629 he retired into Holland, believing that he would not be free in France to pursue his meditations. There he worked at Metaphysics, Anatomy, Chemistry and Astronomy. He composed a "Traite du Monde" as he conceived it, but, hearing of the imprisonment of Galileo, he feared to publish it. Probably the dread of persecution was the cause of his adopting Tycho Brahe's system of Astronomy, according to which the sun and the planets moved around the Earth."

At this date he had published no extended mathematical works. Yielding to the solicitations of his friends, he now gave to the world his "Traite de la Methode," in which his mathematical discoveries constituted one chapter only. He placed far higher value upon his metaphysical writings than upon his mathematical. Posterity has not ratified his judgment in this respect. It is upon the latter that his fame now rests. To him is due the present system of notation by which the degree of involution of a number is represented by a smaller numeral placed above and to the right of the said number, thus making the former the exponent thereof, and displacing the various and cumbersome methods of expression then in use. The method of expressing in Algebraic terms the properties of a curve is his discovery, by which its nature is defined by the relation existing between two variable lines—the ordinates and the abscissa. From the equation thus obtained all the other geometric relations of the curve can be deduced. The inverse proceeding, by which, when having the algebraic formula he could regard the abscissa as the roots of an equation, enabled him readily to solve problems in Geometry that had arrested all antiquity. Among his other discoveries was the rule he has given by which to recognize the number of real roots which an equation may only have, from the alternatives of the signs that have among them the terms which compose it. These treatises on Geometry assure to Descartes an immortal renown. Having rendered him this just homage, we may venture to speak with equal truth in regard to his other writings. The knowledge of the laws of optics was then too limited to permit his studies therein to be of much value now. He added to what was then known, his discoveries as to the true laws of refraction. He pointed out the fact that the only rays that enter the eye of an observer from the rainbow are those which, penetrating the raindrop under a certain angle, are so reflected within it as to become visible to the spectator. His "Theory of Vortices," published in 1644 in the Philosophia Principia, attracted the attention of the world. According to it the sun and each of the fixed stars are the centre of a whirlwind (Tourbillon) or Vortex of finely divided matter, which causes the circulation of matter still more subtile around these centres. In the seventeenth century it was wise to preserve the orthodox immobility of the earth, in order to avoid persecution; therefore the vortex embraced the sun, and the planets circulated around our earth. The subtile matter of this first vortex constituted Descartes' *first element.* He imagined a *second* element like the first, but in which the molecules were round; finally, a third element, formed of molecules furrowed with canals, through which molecules of the other two elements could circulate in all directions! If Descartes in his theory of vortices had had the key to the system of the world, he would not have failed to prove it by calculations, as Newton did with his theory of gravitation; but he was contented to rest satisfied with vain conjectures. It is often said that Descartes had created Newton. So far as Geometry is concerned, it is undoubtedly true; but if experimental philosophy is spoken of, it is absolutely false.

In Descartes' celebrated "Discours sur la methods pour bien conduire sa raison et chercher la verite dans la science," and in the "Meditations touchant la premiere philosophie ou l'on demontre l'existence de Dieu et l'immortalite de l'ame," he started with the fundamental maxim: "In order to attain to the truth, one must strip oneself of all the opinions that one has received, and reconstruct anew the foundations of the whole system of one's knowledge." Obedient thereto, he stripped himself of belief in the testimony of the senses, the existence of the body, of himself, and even of God, and reduced his science to the single fact, the single proposition, the only evidence for him: "Cogito ergo sum" (I think, therefore I am). From the certitude to him of the mind, or of thought, Descartes passed suddenly to the certitude of the existence of God, by means of the axiom in Logic, which he transformed into a metaphysical principle: "The mind can affirm of a thing all that is contained in the idea of a thing." This certitude became for him the base and the guarantee of the human reason in all the acts which form the special domain of human intelligence.

Descartes arrives thus at the proof of the existence of God: "We find that all our ideas of limits, of sorrows and of weaknesses, presuppose an infinite, perfect and ever-blessed something, beyond and including them; that all our ideas converge to one central idea, in which they find their explanation. The formal fact of thinking is what constitute our being; but this thought of which we are certain leads us back to the necessary pre-supposition on which our ideas depend—the ultimate totality, in which they are all reconciled; the permanent cause on which they and we, as conscious beings, depend. We have, therefore, the idea of an infinite, perfect and all-powerful being, which cannot be the creation of ourselves, and must be given by some being who really possesses all that we in idea attribute to him." Such a being he identified with God. But thus far Descartes was confined within the sphere of his own ideas. From this embarrassment he escaped by invoking the veracity of God. He invoked it as the support of the testimony of the senses, which no longer appeared to him doubtful. "Now that I know myself," he says, "and that I know God, I have not the same reason to doubt. All that nature teaches (and by nature I mean God, or the order and disposition that

God has placed in the things created) contains some Truth. I recognize in myself various faculties of thinking: that of conceiving (which belongs only to my mind); that of feeling, and that of imagining, which is only the application of the faculty that conceives to the body that is present, and consequently that exists. Material things, then, do exist, and the impressions received by the senses and transmitted to the soul, which examines and judges them, are not pure illusions." Thus he reconstructed the entire edifice of human cognizance, after having destroyed it to its very base.

The influence that Descartes' writings exercised over Europe was widespread; it was rapid and almost universal and greatest among the most cultivated and liberal-minded. Bossuet, Fenelon, Malebranche, the writers who constituted the celebrated School of Port-Royal, the leading members of the "Oratoire," adopted Cartesianism. Pascal borrowed from it the spirit of discussion which we admire in the "Provincial Letters." The Jesuits gave their adherence later. The University surrendered only in part and at the last extremity.

The great sensation which Descartes caused in all minds could not fail to arm against him the jealousy, ignorance and superstition of many men. They decried a man who attempted to demonstrate the existence of God, the immateriality of the soul, the origin and certitude of our knowledge, otherwise than had been done before him; who worked on a mechanical and general explication of the phenomena of nature. A man, finally, who attacked boldly the Scholastic Philosophy, would naturally alarm those who lived in estate or reputation by teaching all that he overturned. The Roman Catholics took no active part against him, though a decree of the congregation of Cardinals in Rome, in 1643, forbade the faithful to read or to possess either these or any other books of the French Philosophers. In Holland, though he had many advisers and warm friends, there were many hostile to him. Among the professors of Theology in the Reformed Churches he had violent enemies. They accused him of impiety and atheism, and would have had him expelled from the country, had he not applied to the Ambassador of France, who hastened to address himself to the Prince of Orange, and succeeded in quenching the disturbance.

Descartes found that his metaphysical theories, to which he attached the greatest value, brought him incessant quarrels and troubles. He regretted the loss of the peace and quietness in which he had lived. The celebrity he had obtained brought him no equivalent therefor, and he wished he had never published his views. In this frame of mind, Christine, Queen of Sweden, offered him a retreat by giving him a place in her Court. This he accepted. She was very kind to him, and the honor of being sought after by a great Queen served to confound his persecutors. But the change in his mode of life and the early hours of rising, to which he was not accustomed, affected his health. Always very delicate, he was seized with an affection of the throat, and died February 11, 1650, aged fiifty-four years.*

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* J. B. Biot, et Feuillot De Conches, Biographie Universelle, 1855.

CHAPTER VII

THE WRITERS WHO WITH DESCARTES GAVE RISE TO THE CARTESIAN PHILOSOPHY.

A GREAT and original thinker has always among the brightest of his disciples, some, who whilst accepting much of the new doctrine, add to or modify it so as to change even its most prominent features. In this manner at first BARUCH (or Benedict) SPINOZA (1632–1677), in one direction, and later NICHOLAS MALEBRANCHE (1638–1715) in the other, changed and yet confirmed in its essentials the teaching of Descartes, giving rise to what is now called Cartesianism. Descartes' Metaphysics seemed often to hang over the edge of Pantheism, yet always drew back and avoided it. No doubt the fear of the results that might be expected at the hands of the theologians kept him on the safer side. Spinoza had no such fear. A Hebrew by birth and education, he was born with an investigating mind; he took pleasure in asking questions that the most learned Rabbi could not answer. He began to study the Talmud and the Bible in solitude, and to meditate over their contents. The comments that he made when conversing with his friends drew the attention and the censures of the chief men of the synagogue, who required him to withdraw from their assembly. He then at first preferred the society and belief of Christians, but soon retired to his own meditations, to which the works of Descartes gave new occupation. As he advanced in Philosophy he gave up more and more the faith of his Fathers, and forsook the Synagogue forever, abandoning even all intercourse with the Jews. He supported himself by working on and grinding lenses, and lived in the most retired and abstemious manner. His health had always been delicate, and he was physically weak. He died very suddenly in his 46th year.

According to the doctrine of Spinoza, "The illusion of the finite, the illusions of sense, imagination and passion, which raise the individual's life, even the present moment of the individual life, with its passing feelings, into the standard for measuring the universe, is the source of all evil and error to men." "On the other hand, his highest good is to view all things from their centre in God, and to be moved only by the passion for good in general—the intellectual love of God.* The basis around which his conceptions all turn are the *substance* with its attributes and modifications. By substance he understands whatever is, is in itself, and can be apprehended in itself; that is, whose apprehension does not require the comprehension of something else of which it must be formed. This corresponds to the axiom: "Everything that is, is either in itself, or in another; that which cannot be comprehended through something else must be apprehended in itself." † With the idea of substance is united the idea of the cause thereof. By the latter he understands that essential which includes existence in itself, or that, whose nature cannot be thought of otherwise than as existing. The idea of substance is complemented by the characteristics of infinite existence, and of exclusive existence. For he asserts (first) the substance must be infinite; (second) that there can be but one substance. In regard to the first a Scholium says: "Since the finite is a partial negation, while the infinite is an unqualified affirmation of existence, it follows from what has been shown that the substance, coming by its own essence into existence, must be eternal." *

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* Enc. Brit., 9th Edit. Art. Cartesianism.

† "Alles was ist, its entweder in sich oder in einem andern. Was nicht durch ein anderes begriffen werden kann, muss durch sich selbst begriffen werden." (J. Meyer, Kons, Lex'n, Bd. 39—S. 1104. Spinoza.

From the last quoted sentence he derives directly his doctrine of God: "God is to him the absolute, infinite Being, or the substance consisting of infinite attributes, of which attributes each expresses eternal and infinite existence." To Spinoza, God is the thinking and extended substance. In explanation, he says: "One must not think the epitheton of infinity (unendlich) is withdrawn, but the relation is as follows: We dare not say that the extended substance is unworthy of the nature of God. Mobility and motion are ascribed to it. It is active, efficient, energetic, living, engaged incessantly in producing and changing. To the substance, so far as it has extension, is ascribed, not the quiet of death, but unconditional activity." Everything impressed Spinoza as exerting force, everything was animated. Compound substance was regarded as a dynamical whole. The doctrine that everything is animated and alive is essentially peculiar to Spinoza.

From the second attribute of God—Thought—all is excluded that belongs to man's existence. Every trace of anthropomorphism vanishes utterly. God

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* Da das endliche ein theilweise Negation, das Unendliche dagegen, eine unbedingte Affirmation der Existence ist, so folgt schon aus dem Satze, das der Substance ihren wesen nach, Existence zukomnt, dass sie unendlich sey. (Ibid.)

does not need from us that we should ascribe to Him the properties that belong to the utmost superiority, even to the perfection, of the *human* nature. For that reason *understanding* and *will* are denied. Thought, as an attribute of God, does not include the presentation of the idea in itself, but it designates only the possibility of bringing forth ideas. Thought, therefore, is as much as the capacity of thinking. Ideas belong to God only so far as He is thought of as the Intellectus (Understanding); but the Intellectus itself is subordinate to the absolute thought. God is called the free cause (Causa Libera); but that means only that there is nothing beyond himself by which he can be compelled to action. Since he is the only substance, so he acts solely according to the laws of his own nature. Free will or spontaneity in the ordinary meaning of the words (meaning a choice—a rejection of the one and the preference for another, or an absoluteness and sovereignty which from two contradictory and opposed things can bring forth the one equally as well as the other) is strongly denied.

This action of the will is denied because it seems to be incompatible with the idea of the most perfect Being. "God acts from necessity or according to necessary laws. From the infinite nature of God follows all that is infinite in an endless manner and forever with like necessity; exactly as from the nature of a triangle it follows from Eternity, through Eternity, that its three angles will equal two right angles.

"From like reasoning he rejects the theory of a purpose (Teleology), and that God works all things with reference to the good (sub ratione boni). That which is done is good, indeed absolutely good, because the nature of an all perfect Being brings this with it of itself, but not because this Being had either first made a resolution that it all must be good, or because the good presents itself to him as an ideal that he must follow." In a similar course of reasoning he withdraws the love of man from God, and the desire that man should love Him. Spinoza thus, after identifying God with, and as existing in, the nature of man and the material world, ultimately, through his reasoning, withdraws nearly all attributes from him, so that little more is left than the vague, indistinct idea of an eternal, infinite, intelligent existence.

NICHOLAS MALEBRANCHE (son of a Secretary of Louis XIII. and treasurer of a large part of the royal revenues) was born 6th of August, 1638. A certain malformation from his birth that entailed continued ill-health obliged his parents to give him a domestic education until he was able to enter a course of Philosophy, from which he passed to the Sorbonne to pursue his theological studies. His taste for retirement and study led him to join the congregation of the Oratoire. Occupying himself there for some time with ecclesiastical history, with Greek and Hebrew literature, he met accidentally with the "Traite des Hommes" of Descartes. He was struck with the new views of science thus opened to him, and read it and the other works of Descartes with so much eagerness, that he thought he would be able to reproduce them from his own mind if they should ever be lost.

In 1674 he published his "Recherche de la Verite." The general aim of this work, as well as of others that he published later, was to show the accord of the Philosophy of Descartes with Religion. Descartes had given a far more luminous explanation of the union of the mind and body than any of his predecessors. Malebranche expanded Descartes' ideas in regard to the union which we have with the bodies that surround us, and of the mind with God. When investigating the nature of the mind, Malebranche, who believed in the impossibility of a direct communication between mind and body, strove to show that the thoughts of the mind cannot be the physical cause of the movement of the body, nor the movements of the body the physical cause of the thoughts of the mind, because there are no points of contact between the two substances. All that takes place is in virtue of the *general law* that God has instituted:

to excite in our minds certain thoughts, when the movement produced in our organs by contact with foreign bodies will be communicated to certain parts of our brain. Thence it follows that God alone is the cause of all the movements of our body, and of all the affections of our mind, and that He only, speaking absolutely, can render us happy or unhappy.

The doctrine to which the name of Malebranche is attached is that by which man sees *all* in God, and that it is God alone that acts in him. It has thus liens uniting it with Spinoza's pantheism, which considers that all in the world moves by necessity from the nature of God, in whom he sees only the general and the absolute. This is in reality the theory of St. Augustine, who perceives in God only that which is unchangeable, and which modern Philosophy calls necessitarianism. Malebranche's doctrine is equivalent to a negation of free will. Man is an automaton; the fall of man—original sin—conferred on him the liberty of committing evil, and this liberty is man's punishment. As to the animals it is entirely different. Having neither intelligence nor will, they do not know what evil is.

In accordance with Malebranche's necessitarian doctrine, he was led to deny individual providence and even all finite existence. It is not conformable to the nature of God to act by any but universal laws, and these universal laws necessarily involve particular evil consequences, though their ultimate result is the highest possible good.

Malebranche avoided discussing the astronomical and physical theories of either the Ptolemaic or the Copernican system, as well as any other question that would force him into a denial of the established Aristotelian theories of the Church. He escaped, therefore, all persecution, though his denial of particular providences constantly involved him in disputes with Arnauld, with Bossuet and with others. He died in 1715, aged 77 years.

The theories of Descartes, Malebranche and Spinoza, differing, as shown above, in important detail, yet all having the same general foundation, constituted the Cartesian Philosophy. Its principles, held with various modifications, were in the thoughts of the greatest minds of the time; and the philosophy of Leibnitz, Locke, Condillac and others, though they were not within the Cartesian fold, drew much from its doctrines. Its practical and permanent benefits to its age and ours were rather in its destructive action upon the existing errors of its time than (apart from the discoveries in Mathematics) the creation of new thoughts or knowledge. It was preceded in date by the writings of Ramus, Talezius, Patrizi, Campanella and others, all violently opposing the Aristotelian Philosophy. But they destroyed their influence by trying to substitute the theories of Parmenides, (504 B. C.) of Plato, or ideas of their own, equally unreal and false. To Cartesianism is mainly due the rejection of authority in scientific investigation—the downfall of the Aristotelian Philosophy, and the insistance on doubt and distrust of *all* tradition or accepted belief, axioms, or dogmatic teaching in philosophy and science, until satisfactory proof be given to the mind of their existence and truth.

The Deductive Philosophy had for its principle the belief that the human mind was capable, by reflecting upon its own thoughts, of recognizing certain axioms or incontrovertible truths which it was believed necessarily existed, and which, being in the mind, were therefore in nature. From these a-priori cognitions, such as the scholastic doctrine of the Universals, Descartes' "Cogito ergo sum," or Spinoza's idea of substance, there could logically be deduced conclusions that it was difficult to refute. Indeed, it would be impossible consistently to refute them were it not that from the same premises conclusions equally logical, but diametrically the opposite, might be reached by varying the point or line of departure. The mind, thus occupied by its own thoughts only, could not increase its sum of knowledge from the material world. Phenomena, they thought, could best be explained by reference to general principles, or axioms, such as that "Nature abhors a vacuum" to account for water ascending a tube when the air is exhausted within it; that a flame or heated air ascends, owing to the principle of levity; that the sun would breed maggots in a dead dog, for it was the nature of the sun to do so, etc. For the better study of his own mind, Descartes early refused to read any more books. His aim was not to learn, but to think. Even so late as the time of Cowper it was believed to be wiser to think than to learn. He wrote:

> "Knowledge and Wisdom, far from being one,
> Have ofttimes no resemblance.
> Knowledge dwells in heads replete with thoughts of other men,
> Wisdom in minds attentive to their own."*

In the early days, before the Renaissance, nearly all learning had died out in Christian Europe, and that which later was resuscitated into being had been kept from death by the Arabs only, and was warmed into new life by the Moors in Cordova. All Christendom was ignorant, and only the "Clericus" could read. The most learned monasteries possessed only two or three of the works of Aristotle out of the many later recovered, and few or none of the Monks throughout the land could read Greek. It was then both natural and right that all should look back to the books of antiquity as to a treasure-house in which was kept priceless wealth of wisdom, without which they would be no better than the serfs and slaves around them. Learning then consisted in trying to understand the ideas of those who had lived, thought and written a thousand or fifteen hundred years before. To improve upon that thought was absurd, if not in fact sinful. To think as Plato and Aristotle thought, and to look upon the world and its contents as Aristotle had done, was with the monks and with the scholastics the very essence and truth of Philosophy. To such men the only philosophy known was the deductive. It is so to-day with those whose training is only in classical learning, or whose profession or practice obliges them to depend largely upon established precedent and to rely upon authority in the past, for their reason and motive for action in the present.

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* Cowper. The Task. Book VI.

We have now to leave the realm of the pure subjective and deductive philosophy to which Leibnitz, Locke, Hegel, Schelling, Kant and others have added the labor of their lives,and turn to the school of the inductive philosophy that has opened to us our insight into the real infinitude of knowledge.

CHAPTER VIII

SIR FRANCIS BACON—THE ORIGIN OF THE INDUCTIVE PHILOSOPHY AND THE SCIENTIFIC INVESTIGATION OF NATURE.

FRANCIS BACON, Viscount St. Albans and Baron Verulam, Lord High Chancellor of England (1561–1626) was born in London. His father was Sir Nicholas Bacon, a zealous Protestant, for twenty years keeper of the Great Seal, and one of the Commissioners appointed by Queen Elizabeth to take cognizance of the charges made against Mary Stuart by the Scots.

His mother was a daughter of Sir Anthony Cooke, formerly tutor to Edward VI. She was (as mothers of great men generally have been) a woman of excellent mind. She was learned in many ways; had translated and published from the Italian the Sermons of Ochine, and from the Latin those of Jewel. She possessed true piety and all the feminine virtues. Her sons, Anthony and Francis, received their early education at her hands alone. One of her sisters was the wife of the celebrated Lord Burleigh. Francis Bacon, the youngest of three sons, was kept in his early years much at home, his health being always delicate. At thirteen years he was sent to Cambridge, where his rapid progress astonished his Masters. He was only sixteen years of age when he wrote an essay to combat the philosophy of Aristotle, which he saw was better fitted to produce and perpetuate dispute than it was to enlighten the mind. At the age of nineteen he had traveled through much of France, and spent some time at the Court in Paris, where he published an essay on "The State of Europe" that showed surprising evidence of his maturity of judgment.

On the death of his father in 1579 he was recalled to England, and the narrowness of his estate forced him to look for an employment suitable to his birth and position. He devoted himself to the study of jurisprudence with such ardor and success that by the time he was twenty-eight years old he was made Counsel Extraordinary to the Queen. It is out of our province to follow the political positions of Bacon, or to dwell upon the transactions in his life that caused him to be charged with ingratitude to Essex, his former friend and patron; his venality in office, or the abuses committed whilst holding his appointment under the Great Seal. For these he was imprisoned, heavily fined and disgraced. The penalties were remitted, and his imprisonment was for a short time only. Much has been written in palliation of the confessed charges of corruption. It is pretty well shown that Essex was guilty of the political crimes for which he suffered; but it is impossible to find a reasonable excuse for the active part that Bacon took in his conviction, or to see that it was other than a selfish care for his own interest that prompted it.

It is a relief to turn from the actions of the politician to the writings of the man of science. Macaulay rightly says: "The chief peculiarity of Bacon's philosophy is that it aimed at things altogether different from those which his predecessors had proposed to themselves. . . . The ancient philosophers did not entirely neglect natural science, but they cultivated it solely because it tended to raise the mind above low cares and to exercise its subtlety in the solution of very obscure questions. . . . Bacon, on the other hand, valued this branch of knowledge, only on account of its use with reference to that visible and tangible world which Plato and others so much despised. . . . Bacon was not the inventor of the inductive method. He was not the person who first showed that by the inductive method alone new truth could be discovered; but he was the person who first turned the minds of speculative men, long occupied in verbal disputes, to the discovery of new and useful truths. By so doing he at once gave to the inductive method an importance and dignity which had never before belonged to it."

Bacon's two great works are the "De Dignitate et Augmentis Scientiarum" and the "Novum Organum Scientiarum," in which he proposed to substitute Induction for the syllogism that the scholastics had so long used and abused. He maintained that the only way to arrive at the verities in nature is to observe and study nature, not only in the phenomena that present themselves to our notice, but in those that we are able to discover by the way of experimentation. It is not sufficient only to have eyes to perceive; it needs an art to direct the observations; it needs one still more difficult rightly to interrogate nature. To arrive at this double goal he created methods for which he makes rules without number to be used in all the pursuits of science.

In the method of investigation contained in the "Novum Organum" and other works of Bacon no reference is made to the necessary use of deduction. He was so anxious to decry the old philosophy of scholasticism and to substitute for it the new induction that he lost sight of the fact that it was the long perverted a-priori reasoning from inadequate premises arbitrarily assumed, and the dependence solely thereon, that produced the infructuous learning then existing. Bacon himself made little or no practical application of his method. Had he done so he would necessarily have modified the procedure recommended. By excluding absolutely all deduction he deprived himself of the use of Hypothesis, the judicious employment whereof is indispensable to scientific investigation. Bacon's aim, as he repeatedly stated, was to benefit mankind by searching out and revealing the properties and phenomena of nature. The rules he laid down for guidance have not proved as serviceable as he had conceived they would be, and the search for the essences, which he considered the ultimate cause of phenomena, has been abandoned. But he succeeded in awakening all men to the observation of the world around them, and to the supreme dignity of the study thereof.

The principles of the inductive method as now recognized consist—(1st) In a careful and systematic observation of the phenomena or characteristics presented by the substance or the thought under consideration. (2d) In submitting the substance or the phenomena to variable conditions, artificially produced, or obtained naturally by watching for and varying the time or circumstances existing. (3d) In comparing the results obtained in (1) or (2) with other substances or phenomena that have greater or less similarity with those in question; determining and noting the points of similarity or of difference, and repeating the observations indefinitely until a large number of data are obtained sufficiently great to admit of classification. The phenomena common to or in certain groups can thus be shown to be dependent upon causes or phenomena back of them again; and thus continuing to rise from individual phenomena to those of higher generalization, and still higher as observation or experiment may furnish material or occasion, until the cause nearest to the ultimate cause may be reached. In this proceeding a certain amount of deductive reasoning is frequently involved. Causes or conditions have often to be assumed, from which deductions may be made in order to test the existence or correctness of other conditions or phenomena that should be present, if the true theories or causes sought for agree substantially with those that were assumed. This assumption is an Hypothesis.

Bacon's mathematical knowledge was not of a very high order. He stood far behind Descartes, Kepler and Galileo. It was his comparative ignorance as a mathematician that prevented him from appreciating the great discoveries of the latter. He never accepted the Copernican system of Astronomy. He could not conceive the possibility of the movement of the earth around the Sun, which he ridiculed as being an utter absurdity.

The methods of induction first formalized by Bacon have been practiced unconsciously by thousands of persons without reference to his rules and without knowledge thereof. In like manner, before his day, the greatest minds at times employed it necessarily, seeking through it the light of truth and in studying the works of God.

Bacon, as it has been stated, had made no practical application of the rules for investigation that he had announced. In common with most of the philosophers who had preceded him, he made few, if any, observations of natural phenomena. They preferred to theorize as to the causes of the facts they considered established, rather than to verify their correctness by careful research, or to gather new facts by personal investigations. The implements or appliances necessary for such work in many instances were not yet constructed. The beginning of science waited for the men who would watch and experiment. The tools wherewith to work would then also be invented.

CHAPTER IX

THE OBSERVATIONS OF NATURE AND NATURAL PHENOMENA—GALILEO GALILEI—HIS LIFE AND DISCOVERIES.

Galileo Galilei (Galileo), born at Pisa, 1564, died near Florence, January 9, 1642, was the son of a gentleman of noble family, though impoverished. Being one of a number of children, his father could give him but poor teachers; but his desire to learn made him apply himself with such assiduity to his classical studies that he acquired the knowledge of a solid and extensive literature, to which he owed the lucidity of his discourse and the elegance of his writings. He early showed a strong liking and aptitude for mechanical inventions, also much taste and facility in drawing; he was fond of music, and was well versed in its theory and practice. When he was eighteen he commenced the study of medicine, which his father thought would procure for him an easy and honorable livelihood. He also then studied the Aristotelian philosophy. In the latter he could not accept on the faith of another the answers to questions that reason and experiment answered otherwise, nor could he let the authority of Aristotle intervene when his own experience was a better teacher. He boldly defended his own views and combated those of others, so that he acquired the reputation of being obstinate and contradictory.

Before he was twenty years old he made the first of his great discoveries by observing the swinging of the large lamp suspended from the vaulted roof of the church. He noticed that its oscillations were made in equal times, whatever might be their length. He remembered the fact and made use of it fifty years later in the construction of a clock for astronomical observations. As yet Galileo knew little about mathematics. His father feared to let him study therein, lest it would interfere with his zeal for that of medicine. At last, after long persuasion, his father yielded his consent. From that time everything was forsaken for the new study. He delighted in the demonstrations that put him in possession of certain and unquestionable truth, and that gave strength and method to his mind.

Finally his enthusiasm and the progress he made was so great that he was permitted to give up medicine and devote himself exclusively to mathematics. He became acquainted with the Marquis Guido Ubaldi, a cultivated geometrician, who employed him in researches on the centre of gravity in bodies. His marvelous facility in the calculations caused him to be strongly recommended to John de Medici and to the Grand Duke Ferdinand, who gave him the Chair of Mathematics at Pisa when he was scarcely twenty-five years old. He neglected nothing that could serve to justify his elevation, and undertook to establish the laws of motion and to ascertain the solid basis of the laws of nature, not by hypothetical reasoning such as had always heretofore been done in all schools, but by actual experiment. He showed that all bodies, whatever may be their nature, fall with equal rapidity; whenever there appears to be a difference in their relative speed in falling, it is due to the greater resistance of the air caused by a greater extension of surface in the one body than in the other.

These new views excited the animosity of the old philosophers, who tried all in their power to annoy and persecute this bold innovator. They succeeded in obliging him to leave the chair that he held at Pisa, and to return to Florence without any employment. He had a letter from Guido Ubaldi to a gentleman of Florence of the family of Salviati, who received him with great kindness and enabled him to continue his discoveries until he could obtain remunerative employment. One of Salviati's friends, a Venetian named Sagredo, a man of culture and of high standing, obtained for the young mathematician the Chair of that Science in Padua for the term of six years. In recognition of the kindness, Galileo gave their names to the personages in his dialogues who sustained the new and true philosophy. During this time he invented the thermometer and made some other minor inventions. At the expiration of his term at the University the Senate again elected him to a second period of six years, with an increased salary. The sudden appearance of a new star in the constellation Serpentarius enabled Galileo to demonstrate that its position was far beyond the elementary sphere in which alone—according to the philosophy of Aristotle—changes of any kind were possible. In 1606 his professorship was again renewed.

In 1609 it was rumored that the Count Maurice of Nassau had been presented by a native of Middelburg, Holland, with an instrument that made distant objects seem to be much closer and nearer to hand than they really were. This was all that he could learn about the instrument. From this information Galileo proceeded to ascertain how such a thing was possible, by experimenting with spherical glasses in various shapes. After some attempts with such as he had at hand, he succeeded in his efforts, and a few days after presented to the Senate several of his new instruments, with an essay showing what important consequences must result therefrom in navigation and astronomy. This was the invention of the telescope. The imperfect arrangement of lenses made by Lippershey, of which Galileo had heard, and which started him on his own experiments, was at the best only a spy-glass or field-glass, and was fitted only for such limited uses. Galileo was rewarded by the appointment for life to the professorship, with a salary three times as great as he had before received. Galileo soon after invented the microscope, and perfected the telescope so that it might be turned towards the sky. "He then saw what no mortal had seen before him—the surface of the moon, like a land furrowed by mountains and deep valleys; the planet Venus presenting itself in phases that proved it to be a sphere; Jupiter accompanied by the four satellites that surrounded it in its course through the heavens. The milky way resolved into an infinitude of stars that were too small to be seen by the naked eye. He noticed also the various shapes presented by the planet Saturn, but did not resolve the changes into the presence of its ring. He distinguished the spots on the sun, which the peripaticians had declared to be without blemish and incorruptible. From them he deduced the fact of the rotation of the sun on its axis."*

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* Biot. Biog. Univs. T. 15, P. 413.

From the pale disk of the moon that becomes visible when the new or the old moon is seen, he rightly concluded that the effect was caused by the reflection from the earth of the sunlight thereon, it being analogous to the moonlight on the earth. He saw how the movements and the eclipses of the satellites of Jupiter would serve a useful purpose in determining longitudes, and commenced a long series of observations of the planets for the construction of tables for the assistance of navigators. It is with justice that he is considered the real inventor of the telescope as an astronomical instrument.

Galileo was fully aware of the effect his discoveries would have in establishing the truth of the Copernican system of Astronomy and in overthrowing that of the Ptolemaic and of the Aristotelian philosophy. He believed himself at liberty to discredit the errors that had now become too gross and apparent to be longer tolerated. Unfortunately for him, he had accepted the offer of the Grand Duke of Tuscany, who had appointed him Mathematician Extraordinary to his Court, and had loaded him with favors. Galileo therefore moved from Padua, where the power of the Republic of Venice protected him, and where he was free and safe, to Florence, where he was far less so, since the political exigencies of the state of Tuscany made it much more amenable to the dictates of Rome.

Besides making many men envious of his fame and fortune, his writings had excited against him all those who had taught without contestation the old philosophy, and among them nearly the whole body of Ecclesiastics. Some of these maintained that all that he said he saw was pure fiction; others said that they had looked through his glass (lenses) for entire nights, but saw nothing such as he described. One ecclesiastic quoted against him from the pulpit, "Viri Galilaei quid statis aspicientes in Cælum" (Acts 1. 11), by which the Scriptures had evidently intended to put us on our guard against this astronomer, who would try to teach us falsehoods." They also tried to overwhelm him with ridicule. The most effective weapon, though, was to prohibit all teaching of the Copernican doctrine which he had sustained with so much force. It was represented to be false to Scripture, and was denounced as such to the Holy Chair (Saint Siege). Galileo tried to calm the tempest by publishing in 1616 a letter addressed to the Grand Duchess of Tuscany, in which he undertook to prove by citations from the Fathers that the language of the Scriptures was reconcilable with the new discoveries of the constitution of the universe. This served, however, only to give an open field to his adversaries, who denounced him as holding opinions contrary to the Faith. He was summoned to

Rome and obliged to appear there and defend himself. Notwithstanding the proofs he brought of the reality of his discoveries—of the truth and justice of his reasoning, and the evidences he gave of his catholicism, nothing could prevent an assembly of the theologians appointed by the Pope from declaring that "To maintain that the Sun is placed immovable in the centre of the world is an absurd opinion, false in philosophy and positively heretical, because it is contrary to the Scriptures to sustain the statement that the earth is not placed at the centre of the world; that it is not immovable. And, likewise, that a diurnal motion on its axis is also an absurd proposition, false in philosophy and erroneous at least in faith."

Galileo, thoroughly astonished, employed every argument that truth could suggest in the defense of the doctrine that his observations had proved to be really incontrovertible. No attention was paid to his proofs or reasons; and, as he showed himself disinclined to submit to the decision of the Holy office, they forbade him to profess personally from that time forward the opinions that had been condemned. In 1617 Galileo returned to Florence, and, continuing his astronomical labors, gave his energies to accumulating during sixteen years the physical proofs of the movement of the earth and of the constitution of the heavenly bodies. These he embodied in a work in the form of dialogues between the two distinguished Floretinians before named—Salviati and Sagredo—advocates of his new doctrines, and a fictitious third person named Simplicius, who adhered to the peripatician philosophy. The former, who were cultivated and without prejudice, examine, discuss, doubt and draw forth the evidences that convince them. Simplicius, a true Aristotelian, listens to nothing and will understand nothing that is opposed to Scholasticism, and judges only that to be true or false as it accords with or disagrees with his old teaching. The composition and style of the dialogues were perfectly adapted to the interlocutors, and preserve throughout a charm and elegance, with the most happy choice of expression. Galileo endeavored to obtain permission to publish it, and presented it boldly in person to the Master of the Sacred College at Rome as a collection of scientific fancies and novelties, with the request to examine it scrupulously, to cut out everything that seemed to be suspicious—in fine, to censure with the utmost severity anything therein that required censure. The prelate, suspecting nothing, read and re-read the work, gave it to one of his old colleagues to judge of it, and, seeing nothing to be reprehended, gave to it under his own hand his full approbation. To make use of this, however, it would be necessary to print the book in Rome. This Galileo dared not do, since he had many enemies there who would surely frustrate his plans. Taking advantage of an epidemic then raging in Rome, he wrote again to the Master of the Sacred College, asking permission to print it at Florence on condition that he should have it again examined in that town. The Prelate gave him the address of a new censor, but required him to return the former approval to him, so that he might again see the terms in which he had given it. Having received the document, he would make no further answer, though Galileo used every possible endeavor to obtain it. Failing in this, he was obliged to content himself with the approval of the Censor in Florence.

In order to make himself safe from possible consequences, he represented his book to be an apology for the judgment of Rome in condemning the Copernican doctrine. The opening and closing paragraphs thereof were so worded as to support this idea; but the tenor of the dialogues soon disproved it. The excitement and rage among the ecclesiastics at Rome, when it was published, was beyond description. Galileo vainly attempted to escape by alleging that he had submitted his book to the Holy Chair; vainly asserted that he had only presented the two systems of Ptolemy and of Copernicus as philosophical problems, without

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pretending to adopt either one or the other. He had hoped that the kindly feeling manifested by Urbain VIII. in a former visit to Rome would have been effective in his favor; but his enemies had led the Pope to believe that Galileo had depicted him under the guise of Simplicius. Unlikely and foolish as such action in Galileo would have been, the rumor may have wounded the self-love of Urbain, especially as he may have felt the force and truth of Galileo's arguments more keenly than in his position it would have been expedient for him to show.

Despite the strenuous efforts of the Grand Duke of Tuscany, Galileo was summoned to appear before the Inquisition. Notwithstanding his feeble health and his advanced age—sixty-nine years—on February 10, 1633—he was taken to the Palace, Trinité-du-Mont, the residence of the Ambassador of Tuscany, whence, after a few days, he was brought to the Inquisition. They informed him he would be permitted to explain his reasons before the congregation of the Inquisition, and, afterwards, if he was judged to be culpable, they would hear his excuses. In one of his letters, he writes: "The following Tuesday, I appeared before the congregation of the Cardinals, and I began to show them my proofs; to my misfortune they did not seem to grasp them; and whatever pains I took I could not make them comprehend. They cut short my reasoning with outbreaks of zeal, or else spoke only of the scandal I had caused, and always opposed to me the passage of Scripture on the Miracle of Joshua as the victorious proof against me. This made me think of another place where the language of the Holy Book is evidently conformed to popular ideas, wherein it is said that 'the heavens are solid and polished like a brazen mirror.' To me this example seemed much to the point in proving that the words of Joshua might likewise be so interpreted, and the deduction therefrom would be perfectly just; but they paid no attention to it, and I had nothing but a shrug of the shoulders for the reply." On the 30th of April he was returned to the Palace of the Ambassador of Tuscany, but forbidden to leave the enclosure thereof. On June 25th he was brought again before the congregation of the Inquisition, where his sentence was read to him. He was made to kneel before his judges, his head bowed down and his hand placed upon the Holy Gospels. The following words were dictated to him, which he repeated aloud:

"I, Galileo Galilei, of Florence, aged seventy years, being placed here personally in judgment and kneeling before you, Most Eminent and Most Reverend Cardinals of the universal Christian Republic, inquisitors general against heretical malice, having before my eyes the Holy and Sacred Evangels, which I touch with my own hands, do swear that I have always believed, that I believe now, and with God's help I will believe in the future, all that which is held, preached and taught by the Holy Catholic Church, Roman and Apostolic. I have been judged as being vehemently suspected of heresy, for having maintained and believed that the sun was the centre of the world and immovable, and that the earth was not the centre, and that it moved. Therefore, wishing to efface from the minds of your Eminence and from all Catholic Christianity this vehement suspicion conceived justly against me, it is with a sincere heart and with faith not feigned that I abjure, curse and detest the above-named errors and heresies and all other errors generally."

Galileo was not of the stuff that martyrs are made from. No doubt it would have been nobler in him to have remained steadfast to his convictions and to his knowledge of their truth; but he realized at last the danger that he was in, and that he would only destroy himself by attempting to resist the power of Rome. It was only seventeen years before his first citation to Rome that Giordano Bruno had perished at the stake by order of the same tribunal. It was thirty-three years before his own abjuration that Bruno, adhering to the same heresies, refused to recant, and for them died. It can hardly be doubted that in Bruno's case the aim of the Inquisition was to prevent the dissemination of his doctrines, and that his death by fire after seven years' imprisonment was intended not only to stop their teaching, but to serve as a prominent example of the power of the Church and of its determination to forcibly root out all who were persistent in spreading their heresies throughout the land. Only fourteen years later (in 1619) Vanini was burned alive in Genoa for blasphemy!

Galileo's submission was absolute. If it had not been so, there can be little doubt that he would have been closely imprisoned until death relieved him. As it was, the Church obtained all it wished for—the suppression of his revolutionary philosophy, and the absolute denial of his belief in the truth thereof. He seemed not to have troubled himself as to the main doctrines of the Church, and never questioned or deviated from its other authoritative theological teaching; therefore his punishment was light and his even nominal imprisonment of short duration. Within the same year he was permitted to reside at his country-seat near Florence. When seventy-four years of age he lost his sight. He died January 8, 1642, aged seventy-eight years, the same year in which Isaac Newton was born.

Galileo made no additions to Philosophy or to the theories of Science. His great work was in the practical observation of nature, and in the persistence with which he taught, until his arrest, the truth and evidences of the Copernican theories which his discoveries firmly established. The ability with which his views were set forth and the purity and elegance of his style—which, as Hume states, has made his writings classic—contributed much to the dissemination of his discoveries and to his own celebrity.*

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* The above is mainly from Jean Baptiste Biot. (Biographe Universelle, 2 Edit., T. XV.)

CHAPTER X

SIR ISAAC NEWTON—LIFE AND DISCOVERIES IN MATHEMATICS, PROPERTIES OF LIGHT AND LAWS OF GRAVITATION—HIS DISLIKE OF THEORIZING.

NEARLY one year after the death of Galileo (January 8, 1642) there was born at Woolsthorpe, Lincolnshire, England, on Christmas day, 1642, Old Style (January 5, 1643, New Style) ISAAC NEWTON, whose name, inseparably associated with that of Galileo, will remain immortal in the memory of mankind. Newton was the son of a landed proprietor of limited means, but whose family had possessed the estate upon which he was born nearly three hundred years. His birth was premature, and he was so small and feeble that it was thought that he could not live. Very soon after his birth his father died. His mother re-married when he was three years old, but faithfully fulfilled her duties to her child, and gave him an education that would be appropriate to his position as a country squire. He showed a great aptitude for mechanical contrivances, and such a desire to study that he was returned to the school at Grantham, where he remained until eighteen years old, whence, in 1660, he was admitted to Cambridge. Here, under the tuition of Barrow, one of the greatest mathematicians of his time, he thoroughly mastered the Geometry of Descartes and the "Arithmetica Infinitorum" of John Wallis. From the study of the latter, when he was twenty-one years old, he conceived the idea of perfecting it by further developments, and worked out the details of the Binomial Theorem that has since borne his name, and to which he gave the necessary algebraic formula. In this consisted the "method of fluxions" of which Newton then laid the foundation, to be eleven years later re-invented by Leibnitz and presented by him under another form—that of the Differential Calculus—which is in general use to-day. These processes he had worked out before he was twenty-three years of age. He kept them secret, not revealing them even to his former teachers, Barrow and Wallis. It was not until 1668, when Mercator published his work entitled Logarithmo-technia, in which he showed how to obtain the quadrature of an hyperbola, that Newton was forced to produce the proofs of his earlier methods. He presented them to his master Barrow, who was astonished at the number and the value of the analytical discoveries, which far surpassed those of Mercator, that had caused the general admiration of the learned world. Newton seemed to lose interest in his mathematical procedures as soon as they ceased to be novelities to him. He never occupied himself earnestly with two different branches of scientific thought at the same time. His attention was now (1666) strongly drawn to the subject of the refraction of light, in which he had made many experiments with glass prisms. These experiments were begun at first as a mere matter of amusement and curiosity, but soon led to important results. He found that a ray of light from the sun is not a simple and homogenous beam, but is composed of a number of rays of unequal refrangibility and of different colors.

The prevalence of the Plague in the towns of England drove Newton into the country for safety, and put a stop for the time to his scientific work by depriving him of the needed instruments and appliances. He retired to his country house at Woolsthorpe, about 110 miles from London. It was here and at this time that Newton saw the apple fall that set him to thinking on the cause of gravity, and on the movements of bodies uniformly accelerated, to the study of which his "method of fluxions" had been applied. Reflecting afterwards upon the nature of this singular power that drew bodies towards the centre of the earth with an ever-increasing swiftness, and which acted without apparent diminution, on the top of the highest towers or mountains, he thought, why may not this power extend even to the moon, and then what more would be needed to hold it in its course around the earth? The next step then would be to see if the same power would retain the planets in their orbits around the sun. These were but conjectures; but he soon proceeded to verify them by the appropriate calculations. To arrive at the effect of gravity between the earth and the moon it was necessary to use the radius of the Earth for the first factor. This radius, was at that time calculated from the length of a degree on the earth's curvature being equal to sixty miles. From this datum, which was thought to be correct, Newton found that the law that "gravitation was directly as the mass and inversely as the square of the distance between the centres" would not account for the moon's motion around the earth. He therefore laid aside this hypothesis for many years as incapable of verification, until later correct measurements proved the length of a degree to be sixty-nine and one-tenth miles, and not sixty miles, as he had been led to believe.

On the cessation of the Plague, at the end of 1666, he returned to Cambridge. In 1669 he was appointed in the place of Barrow, who had resigned in his favor, to the Chair of Optics at Cambridge. Having thus every facility for his labors, he devoted himself to observations without number, and formed therefrom a complete doctrine of the fundamental properties of light, which he classified and arranged from his experience and experiments only, without any admixture of hypothesis—a novelty as unheard of as were the new properties he disclosed. It was not until 1675 that he communicated to the Royal Society his conjectures upon the nature of light, prefacing his remarks with : "To me the subject is unimportant, since my discoveries are matters of fact, and for their existence independent of any hypothesis;" but added: "I believe I have seen that the heads of many of the greatest savants run strongly towards hypotheses; I will say, therefore, what I am led to regard as the most probable, should I be obliged to adopt one." He then proceeded to describe, nearly as Descartes had done, the probable existence of the imperceptible Ether, in which and by which light is transmitted. Newton thought that light was composed of heterogeneous particles, different from the ether itself, which were emitted in all directions from a luminous body with an excessive swiftness, agitating the ether, causing undulations therein, by which the movements of the said particles, as well as the ether waves themselves, might be accelerated or retarded. The inherent principle of movement in these minute material particles would continue to act upon them, accelerating perpetually their swiftness, until the resistance of the ethereal medium would equal the instantaneous action of the principle, when the movement of every corpuscle would become uniform. The above constituted the main features of his Corpuscular Theory of light, and was compatible with the known facts of the refraction of light and of the color of thin plates, etc., but failed in explaining the phenomena of the double refraction of Iceland Spar, or the dispersive power of different bodies, as well as many other phenomena later discovered, which have led to the rejection of the corpuscular theory and the universal acceptance of the vibratory theory, maintained in Newton's time by Hooke and by Huygens, but rejected by Newton himself.

The renown in which Newton's name is held is especially due to the proofs he gave of the firm establishment of the laws that govern the movements of the solar and planetary bodies, and to the *absolute demonstration* that they are identical with the law that expresses the movement of a body dropped from a heights towards the centre of the earth—the law of gravitation. This law is: "All bodies attract each other with a force that is directly as the mass (the sum of substance) and inversely as the square of the distance." The *originality of the conception* of these relations is not Newton's. Ishmael Bouillau (1605–1694) from metaphysical considerations maintained that the action of the sun upon the planets decreases as the square of the distance; not as Kepler had asserted in the direct ratio of the distance. Jean Alphonse Borelli (1608–1679) explained clearly in his book on the Satellites of Jupiter (1666) how the planets were held in space around the sun by a power that was exactly balanced by the centrifugal force due to their revolution; and therefore there was no need of the solid skies of Aristotle or the Vortices of Descartes to prevent their flying off.

Robert Hooke (1635–1703), who spent a large portion of his life in disputing the priority of his theories and discoveries with his rivals, who likewise claimed them, published in 1674 an essay upon—

1st. The reciprocal attraction of the sun and all the planets upon each other.

2d. The supposition that the heavenly bodies when once in motion would persist in motion in a straight line until some other force would bend or deflect their course into a circle, ellipse or other composite curve.

3d. That the attractive powers exercise more energy in proportion as the bodies upon which they act approach the centre from which they emanate.

In 1679 he wrote to Newton on the nature of the course of projectiles, presenting as a certain fact that an eccentric ellipse would be the consequence of reciprocal gravity in the ratio of the squares of the distances from the centre of the earth. Newton was still unwilling to give expression to his own opinions, since he could not reconcile his calculations of the distance of the moon based upon the diameter of the earth as it was then given. In 1682 he learned that the measure of a terrestrial degree had been lately made with extreme care by Picard. Obtaining the length of a degree thus calculated, Newton returned home, and, taking up his calculations made in 1665, he revised it with the change therein made by the new length of a degree. As he advanced and saw the result it would have on his theories, he became so excited that he could not continue his calculations, and was obliged to ask a friend to complete them for him. This time, the accordance of his theory with the observations was perfect. The effect of weight at the surface of the earth, as drawn from his experiments with the fall of bodies, when applied to the moon—diminishing as the square of the distance between the centres of the respective bodies—was found to be identically equal to the centrifugal force of the moon, and conclusive as to the rapidity of its course and of the observed distances. He who had been held in suspense so many years by the error in the measurement of a degree of the earth's curvature now gave himself to the renewed calculation with a boldness of thought never before seen, and proved by the law above named how the planets and comets were held in place; determined the nature of their orbits; the weight and form of their masses; the oscillation of the tides and fluids that covered them; the precession of the equinoxes and the endless number of other questions thus given birth to. In 1684 Newton showed to Halley—who had come to Cambridge to consult him in regard to the action of centrifugal forces—a treatise he had composed concerning motion (de motio), and which was the basis of his great work, "The Principia."

The latter work, "Philosophia Naturalis Principia Mathematica," was shown to the Royal Society in 1686. The work was published by Halley at his own expense. Among the savants of the time there were but few capable of appreciating the value thereof, and of the few, Hooke and Wren disputed the originality of the discoveries. Huygens even only partially accepted the doctrine of universal gravitation. He applied it to the heavenly bodies, but substituted theories of his own for the movements of bodies on the earth. Leibnitz was led by his metaphysical tendencies to undervalue it, and to suggest methods of his own devising for proving the same truths. Profound mathematicians, among them Jean Bernoutti, combated it later. Fontenelle, though Secretary of the Academie des Sciences for forty-two years, would only consider the laws of attraction as being more than doubtful, and through his long life held firmly to the Vortices of Descartes. The three "Laws of Motion" given by Newton still remain without change or addition. They are:

1. That of Inertia. Every body continues in its state of rest, or of uniform motion in a straight line, except in so far as it may be compelled by force to change that line.

2. Change of motion is proportional to force applied, and takes place in the direction of the straight line in which the force acts.

3. To every action there is always an equal and contrary reaction, or the mutual actions of any two bodies are always equal, and oppositely directed.

It was more than fifty years after its publication that the truths demonstrated in the Principia were even understood, much less embraced by the generality of savants. After the completion of his great work Newton confined himself to working out the details of his former labors, and did not enter into any new scientific work. He suffered much from sleeplessness, which was aggravated by the vexatious disputes into which he was drawn by Hooke, by Leibnitz and by others with reference to the originality and priority of his discoveries, which in 1693 so injured his health that for many months afterwards his reason was affected. Rest and quiet restored him; but in his works on optics that appeared in 1704, and in later works on science, he always stated that they were titles of ancient works that he had composed long before, and in which, though they needed revision and extension, of which he felt the necessity, in order that they might be nearer perfect, yet he could not bring himself to undertake the work. The appointment to the Directorship of the Mint in 1699 gave him a competent livelihood. In 1703 he became President of the Royal Society of London, which he retained for twenty-five years, until his death. In 1705 Queen Anne knighted him. The disputes between Leibnitz and Newton concerning the differential calculus continued with increasing acerbity until the death of the former in 1716. It must be said that each was unjust to the other, and Newton was even more so than his opponent.

Newton was a believer in the science of Alchemy. He pursued his experiments in the search of the Philosopher's Stone until late in life. The familiarity with chemical reactions thus obtained was of service to him when he was placed in charge of the

Royal Mint. In the latter part of his life Newton published a "Chronology of Ancient Kingdoms," that he had composed when at Cambridge, founded on the astronomical observations of the ancients. After his death were published a number of dissertations upon the prophecies contained in the Scriptures, which he considered embraced a mystical meaning. Such conjectures were in accordance with the custom of many men of science of his time. No particular value is attached to these papers. Many other of his writings of the same nature remain unpublished. Newton never married. His health, after recovering from the attack before named, was excellent until he was eighty years old. He never required the use of glasses to aid his vision and never even lost a tooth. When eighty-five he suffered for about twenty days from the presence of a calculus. Two days before his death he lost consciousness. He died March 20, 1727.*

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* The notice of Newton is mainly drawn from Jean Baptiste Biot's exhaustive article in the Biog. Univ.—2d Edit. T. 30.

CHAPTER XI

THE EXISTENCE OF THE ETHEREAL MEDIUM—TRANSMISSION OF LIGHT AND HEAT.

It has been mentioned that Newton considered that Light was caused by material corpuscles emitted from a luminous body and moving with an extreme swiftness through the interstellar Ether, to which it transmitted motion, and by which it ultimately reached the eye of the observer. The action of gravitation in causing the movement of bodies towards each other, and of the planets and satellites in their orbits, he thought was also due to the existence of such a medium, filling all space. The doctrine of direct action at a distance, by which one body could influence another body not in contact therewith, nor with any intermediate substance, in his opinion was absurd. In his letter to Bentley he wrote: "It is inconceivable that inanimate brute matter should, without the mediation of something else which is not material, operate upon and affect other matter not in contact, as it must do if gravitation in the sense of Epicurus be essential and inherent in it . . . That gravity should be innate, inherent and essential to matter, so that one body can act upon another at a distance, through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it." He sought for the explanation of gravitation in the existence of an ethereal medium at an early date, but found that he was not able from experiment or observation to give a satisfactory account of this medium and the manner of its operation in producing this, the chief phenomena of nature.*

The lapse of nearly two hundred years has left the problem of the nature of the ethereal medium still unsolved, and even the possibility of its non-existence, and of the action at a distance of matter upon matter, has still its advocates; so far at least as the cause of the *weight* of matter or *gravitation* is concerned.

The recognition of the fact that radiant heat, light and electricity are modes of motion only, and the accurate knowledge we now have of the laws governing the phenomena presented, in their transmission and conversion into other forms of physical and chemical energy, constitute the greatest and most important part of the foundations of modern science. The theories of light, heat and electricity now claim almost without dispute the existence of the ether filling interstellar space as the postulate of their being, since they are but the vibrations or the undulations thereof, and without which, they are not.

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* Enc. Brit. 9th Ed. Art Attraction.

The nature of the Ether and its constitution has been the object of thought of men from the earliest historic times. About 500 B. C. Xenophanes and the Eleatic School believed in the immutability, the unity, the continuity and the immobility of matter, and that the evidences of the senses were illusions only. Leucippe, in opposition thereto, taught that matter was like a sponge, in which the atoms are separated by vacous spaces, the atoms being solid, impenetrable and almost infinitely small. All bodies are composed of this assemblage, or union, of the plenum and the vacuum. The atoms are of various shapes, and when grouped in various ways give rise to the different kinds of matter. His disciple, Democritus (470 B. C.), taught what is now nearly the accepted doctrine: "Nothing is made of nothing, nor can anything be resolved into that which is not. Therefore, all that *is*, is composed of principles self-existing of themselves. These principles are the atoms, and the vacuum is the space between the atoms. . . . The atoms are infinite in number, as space is in capacity. The atoms are of such tenuity that they escape all perception. Their solidity renders them indestructible. Their shape is infinitely varied. These atoms are the primitive bodies which move in that infinite space that admits of no relations of position, indicated by such words as high, low, the middle, or the extreme. The movement of the atoms has had no commencement: it is from eternity. By it (the motion) the atoms are attracted, repulsed, are united, are separated. From the unions and from the separation result the composition, and the decomposition of all bodies. Bodies only differ among themselves by the number, the shape and the reciprocal composition or decomposition of the groups of atoms which compose them. The worlds themselves disseminated in infinite number throughout infinite space, whatever may be their relative equality or inequality, have no other origin, and are submitted to the same variations. The rapid movement of the atoms is the soul which penetrates these worlds as with the action of fire.

Fire itself is composed of round atoms, always in agitation." *

Epicurus (342–270 B. C.) adopted Democritus' idea of the atoms, to which he added the properties of weight, thus constituting gravitation and affinity, which constitutes the germ of Chemistry. It is the philosophy of Epicurus that Lucretius expounds in his poem "De Rerum Natura," much of which reads almost like a modern treatise on Physics. Lucretius argues that space must consist of atoms of material substance, separated one from another by vacuous intervals. He insists elsewhere that they must also be in constant motion. These are conditions that the modern atomic theory of the Ether likewise requires. He writes: "Thus if there was no such thing as space vacated, or a vacuum, everything would be solid; then, again, unless there were some things solid to fill up the space, everything, all, would be empty space. Body from space is in itself distinct, for all is neither full nor is all void, and thus there are solid atoms which cause the difference between the plenum and space. These solid atoms by no force from without can be dissolved, nor can they be destroyed by being penetrated from within, nor made to yield by any other means, as I have taken pains to show. For no things can come in collision or be

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"Democrite"—par Etienne Pariset. Biog. Univ. T. 10, p. 387.

broken, or by force be cleft in two, or receive moisture or the piercing cold, or the searching fire which all things else destroy, without a void."*

Lucretius here opposes, as he does throughout his work, the Eleatic doctrine taught by Xenophanes (617–510 B. C.), and later by Parmenides (504 B. C.): "That the world is *one*, immutable, unmovable and indivisible: that it fills all space, in which there is no void, no vacuum, consequently there can be no movement, for there is no place to move to. The senses, it is true, testify that there is a plurality in composition and in things, but the senses are fallacious and illusive, and must not be received by the reason. Space is a plenum, and is indivisible and continuous, infinite and cannot be divided." In other words, Xenophanes accepts the geometrical idea of matter and of space. A figure that is continuous and that can be infinitely divided only by destroying it.

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* De Rerum Natura.

Tum porro si nil esset, quod inane vacaret,
Omne foret solidum. Nisi contra corpora caeca
Essent, quae loca complerent, quaecunque tenerent:
Omne, quod est, spatium vacuum constaret inane
Alternis igitur nimirum corpus inani
Distinctum est, quoniam nec plenum naviter exstat,
Nec porro vacuum. Sunt ergo corpora caeca,
Quæ spatium pleno possint distinguere inane.
Hæc neque dissolvi plagis extrinsecus icta
Possunt: nec porro penitus penetrata retexi;
Nec ratione queunt alia tentata labare:
Id quod jam supera tibi paulo ostendimus ante.
Nam neque conlidi sine inani posse videtur
Quidquam, nec frangi, nec findi in bina secando:
Nec capere humorem, neque item manabile frigus,
Nec penetralem ignem, quibus omnia conficiuntur.
(Lucretius—De Rerum Natura. Lib. 1. 521.)

Leucippe, Epicurus and his disciple, Lucretius, on the contrary, assert the numerical idea—that matter is discontinuous; we pass from one number to the next, *Per saltum;* the numbers being individuals, and building up the sum or body by their aggregation, which body can be again divided into its original numerals, or individual factors, the atoms.*

Modern science is still somewhat in doubt between these conflicting views. The laws under which the transmission of light and heat from the sun to the earth and other planets, and the transference of heat on earth from one body to another by radiation, are fully established. They are demonstrated facts. Their phenomena necessitate the assumption that there is *something* that exists throughout infinite space—between us and the far distant star—that even the latest and most powerful telescopes fail to reveal: so far off that its light even then is not directly perceptible to human vision, but proves its presence through the slow action of the telescopic camera upon the photographic plate.

This *something* is set in vibration by the sun, or other star that is intensely hot. The undulations, or transverse vibrations, are transmitted from the sun with the speed of light, for they *are* light, through the intervening minimum distance of 91,430,000 miles with a velocity of more than 186,000 miles a second, thus requiring eight and one-third minutes for them to reach the earth. The light from the nearest fixed star, a sun to other worlds, requires three years to reach us; from the most distant stars hundreds, if not thousands, of years. These vibrations of the ETHER, for such it is called, are of course without other action upon the intervening space, which contains only the ether itself, and pass with little action through our atmosphere; would probably do so absolutely without action if the air consisted only of oxygen and nitrogen gases, its main and essential constituents. The heat *directly* absorbed by the air from the sun's rays is almost nothing; nearly all its heat is derived from contact with the *earth*, which is heated by the sun's rays; the higher we ascend a mountain, or into the air by means of a balloon, the colder the air becomes. The presence of foreign gases, carbon dioxide, ammoniacal gas, the vapor of water, and even the odor of plants and other organic matter, increases the absorptive or heat-retaining power of the air, in some cases one hundredfold, in others many thousand times. This especially is the case with heat of low intensity, of which much more relatively is retained than when it is of high intensity. The temperature of the atmosphere is thus regulated; for if the earth radiated its heat away as readily as the solids of the earth receive it from the sun, the temperature even of the tropics would be 200 degrees C. below freezing.*

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* J. Clerk Maxwell, Ency. Brit. 9th Edit. "Attraction."

The undulations of the ether are excessively rapid. Those which affect the eye and produce vision vary from 370 million million per second in the ultra red rays of the spectrum to 833 million million per second in the ultra violet rays; these rays have respectively a length inversely to the rapidity of vibration of from .0000205 of an inch to .00000914 of an inch, or, in round numbers, say 20 one-millionths of an inch for the extreme red, and a little over 9 one-millionths of an inch for the extreme violet.

These rates of vibration may be better comprehended when compared with the undulations of the atmosphere, which undulations constitute musical or other sounds, audible to the human ear. Sound is produced by the air being thrown into alternate expansion and contraction by the vibrations of a string, metallic surface, or by the air itself, if set vibrating in a tube with an open end. It propels itself by alternate swellings and contractions, as it were, of concentric spheres (not as light does by transverse vibrations), and travels at the rate of 1089 feet a second.

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*Langley in "Barker's Physics."

Its rate of vibration varies from the minimum of 16 in a second, the lowest rate of audibility, to about 40,000 a second. The range of musical notes is from 32 vibrations a second—the lowest note of the organ—to 4224 vibrations, the upper notes of the pianoforte, or 4752 of the picolo. The human voice ranges from 87, for a bass voice, to 1530 a second, the highest soprano. The length of the sound wave varies inversely with the frequency of the vibrations; a high note has a shorter length than a low one. The average wave length in conversation, for a man's voice is from eight and one-fourth, to ten feet; for a woman's voice from two to four feet. The relative speeds, therefore, with which light travels through the ether and sound through the air are:

Light—186,000 miles in a second.

Sound—1089 feet, or about *one-fifth mile* in a second.

Light travels, therefore, 907,000 times faster in the ether than sound does in the air.

The number of vibrations are inversely as their length. The length of the vibrations of the violet rays is $\frac{9}{1,000,000}$ of an inch; the length of the vibrations of the average waves of a woman's voice is about three feet; therefore the sound waves are four million times longer than the waves of light.

The number of the vibrations of violet light being

883 million million in a second, and the fastest known sound vibrations being, say, 40,000 in a second, light vibrations are 22,075 millions to one sound wave. These relations are given merely to show how almost infinitely minute and rapid the undulations of the ether are compared to those of the atmosphere. How almost inconceivably smaller than those of air must be the ultimate particles of the ether if it is composed of discrete particles as all other forms of matter are. How easily, therefore, they might interpenetrate all other matter, even though the constituent atoms of the air and of fluids are so minute themselves as to escape all tangible or occular demonstration.

Maxwell says with regard to the theory of a semi-solid or *continuous* constitution of the ether: "The theory opposed to the atomic structure of the ether and of matter, generally known as that of Anaxagoras, in which bodies that appear to be homogeneous and continuous are so in reality, as Xenophanes taught, is incapable of demonstration. To explain the properties of any substance by this theory is impossible. The properties of such substances—if existing—could only be admitted as ultimate facts." There is no explanation, for it cannot be explained.

The Vortex theory, suggested by Von Helmholtz, and elaborated by Sir William Thompson (now Lord Kelvin) over thirty years ago, as applicable to the constitution of aerial matter, and of atomic structure generally, and by which theory the permanence and strength of the molecular combinations might seem to be assured, has failed, notwithstanding its ingenuity and beauty, in obtaining corroborative proof. Lord Kelvin, to whom the Hypothesis of the atomic vortex rings is due, lately announced at a special meeting of the American Philosophical Society, November, 1897, in a discussion between himself, Prof. Barker and other members of the Society, "that he had been unable to add any facts or suggestions even, to the original conception; and he was forced to say that he felt compelled to abandon it as a working hypothesis, for want of any sufficient base for theory, from observations or from experiments, other than those of the smoke-rings which he originally described." Nevertheless, it offers the possibility that the structure of the *chemical atom*, and, therefore, of matter, may be due to the formation of vortex rings or some analogue thereof from the ultimate atoms of the ether. As Maxwell writes: "If two vortex tubes are linked together they can never be separated, and if a single vortex tube is knotted on itself it can never become untied. The motion at any instance of every part of the fluid, including the vortex rings themselves, may be accurately represented by conceiving an electric current to occupy the place of each vortex, the strength of the current being proportionate to that of the ring. . . . He who dares to plant his feet in the path opened up by Helmboltz and Thompson has no other properties to work with than inertia, invariable density and perfect mobility. . . . The difficulties of this method are enormous, but the glory of surmounting them would be unique."*

The theory of the ether satisfactorily accounts for the transmission of light and heat. The movement of the Electric and Magnetic radiant waves has been proved to be of a like nature, or rather radiant heat, light, electricity and electro-magnetism are forces essentially identical each with the others: they are governed by the same laws and have the same method of transmission. The existence of the Ether is now asserted absolutely, so that the text-books of our Colleges place the study of the phenomena of Radiant Energy, or Light, Heat, Electricity, Magnetism, etc., under the heading of the *Physics of the Ether*.

Notwithstanding the statement of Clerk Maxwell that the theory that attributes a homogeneous and continuous structure to the substance of the Ether is impossible of demonstration and incapable of any explanation, yet it is generally assumed by mathematicians that the Ether consists of a jelly-like sub-

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J. C. Maxwell, Enc. Brit. "Atom."

stance, perfectly continuous: not granular or molecular like ordinary matter; subtile, incompressible, pervading all space and penetrating between the molecules of all ordinary matter. It also possesses rigidity, and it is thought in so far must be a solid! It is with reason, therefore, that L. Graetz, of Munich, one of the latest mathematicians and writers on the subject, and who apparently accepts this idea of the Ether when free in space, should say: "The various Ether theories embrace many imperfections. Properties are attributed to it that are widely different from those of any other known bodies."*

Even in the ideas of the same person views are held absolutely incompatible one with another. It is not to be expected that the Ether should possess properties similar to other known bodies, but the properties as attributed to it by any theory should not be self-contradictory or otherwise impossible. All theories, however, of whatever kind, as well as our daily experiences, agree in asserting its exemption from all gravitic action. This condition is not an assumption, for the very definition of the Ether separates it from all ponderable matter.

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* Den versehiedenen Ether Theorien aber haften noch vielen Unvolkommerheiten an, es werden in ihnen dem Ether Eigenschaften beigelegt die ganz abweichend von den Eigenschaften der sonst bekannten Körper. Daher gehört der quasilabile Ether Lord Kelvin's; ferner der quasirigide Ether derselben, den auch Sommerfeld und Reiff so wie Bolzmann acceptiren, und dem Sommerfeld ausser dem, in den Leitern, Quasiviscoscität zugeschrieben wird.

Annalen der Physik, No. 6, 1901. L. Graetz, München, März, 1901.

The theory proposed by L. Graetz is that the Ether, though an elastic, solid body when free in space, yet in the interstices of ponderable matter undergoes a process of dilation and expansion consequent upon the reciprocal action and reaction between it and the molecules of matter, which he attributes to the electrostatic energy of the ponderable molecules. He speaks of the kinetic energy of the Ether, but brings no evidence thereof or of its mode of action. He considers the phenomena of static and motor electricity as essentially those of ponderable molecular matter, in which the Ether plays only a secondary part. The origin of the reciprocal actions between the molecules and the Ether is attributed to the molecules of ponderable matter, but no cause for or origin of the needed energy is assigned or suggested. The same difficulty applies to any modification of a theory of a solid continuous Ether. Whence and when can energy arise?

THE ATOMIC THEORY OF THE ETHER here given is essentially that of Le Sage and of Preston, to which the present writer has added the conception of the IONS as being the cause of Static electricity. The Ether is supposed to be composed of molecules consisting of two atoms of non-gravitic matter possessing polarity, the *Ions* of the molecule, but which united in a molecule moves and acts as a unit. These molecules are extremely small and move in all directions with enormous rapidity through free paths exceeding even planetary distances in length; they are individually, absolutely elastic, are relatively close together and move with such extreme swiftness that with their excessive minuteness they interpenetrate the interstices of all ponderable matter. They are of infinite number and of uniform nature. According to Newton's first law, that of *Inertia*, their rapid translatory motion is self-inherent; that is to say, not dependent upon any other pre-existent motion for their continuance. According to his second law, that of *Motion*, any change of motion must be proportional to the force applied and in a straight line in the direction of the altering force. They thus form in free space a consistent isotropic medium of extreme tenuity, but which, owing to the enormous velocity of its molecules, possesses great rigidity, since the moving corpuscles, having a momentum equal to their individual mass multiplied by the square of their velocity, will require a force as great as their own to deflect them at right angles from their path and position. This velocity must at least equal that of the supposed corpuscles in the Kathodic rays, which J. J. Thompson estimates at 40,000 kilometers a second, though probably much greater.* Thus constituted the Ether forms the medium whose *vibrations* produce the phenomena of radiant heat, light and electricity in a manner somewhat analogous to the transfer of sound by waves of the air. The air is known to be composed of gaseous molecules moving in all directions with great rapidity, but yet it acts as a molar medium to receive and transmit together without confusion the often varied and extremely complicated vibrations that constitute Sound. Thus the Ether somewhat resembles a gas, but differs therefrom by being throughout of uniform density and in being non-compressible, since it penetrates through all bodies and cannot be confined; nor can it be compressed as air is by its own mass, for it is not *ponderable* matter, not being affected by gravity. The vibrations of radiant heat, light, etc., which it transmits are transverse vibrations—perpendicular to the line of transition (not like the aerial vibrations that constitute sound, the waves of which are in the line of transition and are like the alternate swellings and contractions of concentric spheres). It is this fact, that the etheric waves are transverse vibrations, that has seemed to require that the Ether should possess the incomprehensible kind of solidity often ascribed to it, so that it might have the desired rigidity to receive and transmit the transverse vibrations of light, etc. But an even greater rigidity would be presented by the kinetic structure of the Ether as here assumed, for, commensurate with the size and rapidity of motion of its molecules, it would offer greater resistance to any change of position or motion than would be possible with the conditions of a jelly-like impalpable solid. The vibrations that constitute Light, etc., seem always to arise from pre-existing vibration in heated ponderable bodies: they have been long studied and are well known. They do not require now to be considered, though their origin will be so later.

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* The latest experiments (1902) give about half that of light.

It is generally accepted that the phenomena presented by Static Electricity are closely connected with the Ether, but in what way and what is the nature and origin thereof are questions very imperfectly answered. Hertz's experiments have demonstrated the identity of radiant electric waves with those of light and heat, differing only in their greater length and consequent slower vibration; but of Static Electricity we have yet much to learn. The atomic theory of the ether should throw some light upon it. It is admitted under every theory suggested that all ponderable substances are inter-penetrated by the Ether, which fills the intervals between their corpuscles. With a continuous jelly-like or solid ether no interaction between the substance of the latter and the corporeal molecules of ponderable matter other than the possible transmission of heat by contact seems probable, for, being a continuous substance, it would have no power of motion or change of place.

The Atomic Theory of the Ether supposes its molecules to be composed—as most ponderable molecules are—of two atoms, their Ions, each possessing strong affinities for the other; the one having positive polarity, the other negative polarity; united in the sense and in the manner that chemical substances unite (for instance, a molecule of free Oxygen is composed of its two Ions—one atom each of oxygen united into one molecule). When the rapidly moving ether molecules come in contact with the earth or other ponderable matter their motion would be arrested in part or in whole. Some of the molecules might pass through the substance, or mass, and continue their course unimpeded or with lessened motion; another part would transfer their motion to the arresting molecules, partly as heat, and would cause in them those peculiar molecular vibrations that we know all matter to possess, whether gaseous, fluid or solid. Still another, and perhaps the larger portion would continue translatory motion, but with far lessened speed, in driving onward or inward the ponderable molecules or masses; the energy of the rapidly moving ether molecule being thus transformed, but never lost. Lastly, the ether molecules themselves thus brought into intimate contact with ponderable matter would be dissociated by these changes of energy into their Ions, which, acting inductively upon the Ions of ponderable matter according to their chemical nature and polarity, would remain in contact therewith, though lightly held, or, finding better conductors near, pass off into the earth and disappear. In this manner all bodies of different chemical structure would retain what might be called adhering dissociated ether atoms of opposite polarities to their own. If in contact with other bodies or with the earth, the Ether Ions held by one substance would induce the opposite polarity in the other substance; consequently the polarities would be balanced; but on removing the one body, which would require force or energy to do, the polarity of the Ether Ions will be unbalanced. The Ether atoms of one of them will flow to the earth; those of the other, if it is a poor conductor, will remain unbalanced and lightly adhering, consequently show *Static Electricity!* For this reason the forcible displacement of dissimilar bodies always manifests *Electricity.* A well known and established fact.

The question *why* and *how* does a metal convey electricity offers another problem. All substances are to some extent conductors. No substance is absolutely a non-conductor. It is a difference in degree—though there is a very great difference. It is known that in all conductors the current passes on the surface or outside of the wire—not through the substance or central mass thereof. The said conductor or other electrified body is surrounded by what may be called an atmosphere, better known as an "Electric field." This may be its origin: When the Ether atoms are stopped or checked by matter in their path, they must be differently affected by the nature of the opposing body. Some substances will more easily permit their onward passage than others. Those that are best fitted by their inherent structure, or by their Ions, to arrest the onward move of the Ether atoms by converting their energy into the molecular vibrations of ponderable matter, will necessarily be surrounded by a greater number of quiescent or partially quiescent dissociated ethereal Ions, while poor conductors would have but few thereof. These quiescent Ions would soon again be brought into motion by other free moving Ether atoms, and with them be swept away; but the rain of Ether atoms is incessant, and the electric field would be quickly recruited by countless thousands of other dissociated Ions replacing those that have moved away. The Ions of an unbalanced electric charge—such as lately described—whether positive or negative, would run with lightning speed through this accumulation of Ions, each one inducing opposite polarity in those in advance of it. If the terminus of the positive wire is the anode of a galvanic battery, the Ions thus developed will effect the usual decomposition of the electrolyte; or, if otherwise connected, give an *electric current.*

It is probable that the pressure of the dissociated ether atoms is the cause of the firm adherence of air or other gases to the surface of all solids, which, as Gmelin states, is so strong that they cannot be removed by exposure in a vacuum. It is well known that the adhering gases can only be removed from barometer tubes by boiling the mercury therein. The Torricellian Vacuum cannot dislodge them. The application of the heat of ebullition, or, in other words, the molar vibrations of the ether, readily remove all traces of the adhering gases.

It may be urged that the general formula—"The energy of the moving Ether molecules equals half of their mass, multiplied by the square of their velocity"—is inapplicable to the Ether molecules, inasmuch as by the definition of the Ether it has no *mass* in the sense of weight. It is not ponderable matter; its molecules would not have mass. Consequently, under the above formula, the mass being 0 (Zero), their momentum and energy would also be zero. In a mathematical equation this necessarily would be true, but the fallacy involved is the ascription of the terms of gravity to a non-gravitic body.

Because all ponderable masses, gases included, are subject to and are measured by the so-called attraction of gravitation, it does not follow that a form of matter cannot exist that is not so attracted or acted upon, though otherwise like matter in general. If it is assumed that the translatory motion of the ether molecules are the cause of gravitation, it is self-evident that the molecules themselves that cause gravitation cannot be affected by gravity, for the same reason that the *isotropic* vibrations of the molar Ether, constituting radiant heat, light and electricity, do not and cannot heat or otherwise affect the intermediary ether through which they pass, not even warming the transparent air (if pure) with the molecules of which the Ether is mingled. In other respects the properties of the molecules would resemble those of other matter, though of great tenuity. They would have a definite size, volume, impenetrability, atomic structure and polarity; they would be subject to the same laws in relation to momentum and energy that govern other matter, though these relations cannot be expressed in the terms applicable only to ponderable matter. Apparently the Ether atoms, like the gases lately discovered—Argon, Helium, Xenon, Krypton and Neon—are devoid of chemical affinities, though in the absence of *weight* the numerical relation of the Ether atoms to those of ponderable atoms would be impossible to discover. It should be borne in mind that the theory of a solid ether presupposes likewise that it is not gravitic.

CHAPTER XII

GRAVITATION AND THE PROPERTIES OF MATTER—THE KINETIC THEORY AND NATURE OF GASES.

THE phenomena of Gravitation remain still unexplained. The ordinary conception of gravitation is that it is the *attraction* or drawing together (from "Attrahere," to draw to) of one body towards another. It seems impossible to explain this *drawing* action of mass acting upon mass. A solid ether without movement cannot explain it, and the atomic theory of the ether can do little if any more. It is evident, however, that the same movement of two bodies towards each other can be produced by pressure exerted from outward towards each other in the straight line of their respective centres. It is probable that in all cases where apparent attraction exists, or even its opposite, repulsion, that the real motive force is that of the pressure of the surrounding medium; the difficulty is to demonstrate the existence and the cause of the external pressure. The laws or conditions under which gravity or the attraction of gravitation manifests itself are well known. That it acts upon all matter directly as the mass, and inversely as the square of the distance between centres, and that a falling body near this earth moves with a constantly accelerating speed of nearly thirty-two feet per second. But what is gravity? What is the force that acts and causes one mass of matter to move towards another mass, or when in contact presses them forcibly together? It is a question so difficult to answer—if it can, even in part, be answered at all—that in the modern text-books of Physics no attempt is made to explain it. Prof. Barker, however, states: "A study of other forms of attraction has resulted in concentrating the attention more closely upon the Ether intervening between the two attracting bodies than upon the bodies themselves. . . . Whatever the seat of the energy, however, whether in the attracting masses themselves or in the surrounding medium, the general attraction which is exerted between masses of matter has received the name of gravitation, while that exerted between the earth and bodies upon its surface is called gravity."

The reasons why the study of the causes of gravitation has made so little progress are twofold: First, the knowledge of the laws that *govern its action* is so accurate, and so fully satisfies all the demands for the practical application thereof, that investigation into its abstract nature becomes to most men a matter of indifference, or a question of ontological interest only; and secondly, the inherent difficulties in the attempt! We are surrounded on all sides by the effects of gravitation, and our every movement and action helped or hindered thereby; yet *it*, of all the phenomena around us, is the only one that we can in no way change, influence or direct. No human contrivance can increase or diminish its force or its rate of accelerative motion. Magnetic attraction, that varies also inversely with the square of the distance, can overpower its force, but only as a cord might drag or hold up a body that else would fall; but it can in no wise be correlated therewith. Countless experiments have been tried by means of heat, chemical action and otherwise, to modify the phenomena that gravitation presents, but all with negative results. It has been impossible to apply inductive and empirical reasoning thereto. The only hope of success lies in the deductive method: assuming an a-priori hypothesis and testing its validity by the few known facts we may possess.

The only hypothesis of the *cause of gravitation* that, in the opinion of J. Clerk Maxwell, "was ingenious, and that has been so far developed as to be capable of being attacked and defended," has been already mentioned under the title of the Atomic

Theory of the Ether, formulated by George Louis Le-Sage; born in Geneva, 1724; died there in 1803. He adopted and perfected the ideas of Leucippus and Democritus concerning the atoms. These theories he published under the title of the "Lucrece New-tonian" in the "Memoires de l'Academie Royal," Berlin, 1782. The latter treatise served as a basis npon which S. Tolver Preston * has expanded the supposition of Le-Sage into the present theory as already described, and also as being the cause of gravitation. The Ether is supposed to be composed of ultimate atoms. They are excessively minute and move with extreme swiftness, constituting a medium somewhat of the nature of a gas (the properties of gases will be described later), but in which the particles are almost infinitely small, and move in all directions with a swiftness greater perhaps than the transmissions of light itself. These particles move through free paths of possibly greater length than even planetary distances. It is known that the speed of motion and the length of the free path of a corpuscle—*i. e.*, the distance it can move without collision with another corpuscle—is inversely to the square of the size or diameter of the corpuscles.

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* London, Edinburgh and Dublin Philosophical Magazine and Journal of Science, 1877, *et seq.* See also the Encyclopedia Brittanica, 9th Edit.

Clausius states: "The mean length of the free path of the particles of a gas increases in proportion as the square of the diameter of the particle diminishes. By assuming the particles to be small enough, the mean length of its path may be increased to any extent. A-priori, one size of particles is as probable as another. The minute size and high velocity would render it possible that no disturbance would be caused amongst the molecules of ordinary matter. This high velocity is necessary to accord with the known facts of gravity. Sir William Thomson has pointed out that the distance through which gravity is affected (*i. e.*, that one body should act upon or attract another) is dependent upon the mean length of the path of the particles. By assuming the distance of the fixed stars (not a star and its planets) to be a multiple of the mean path, it would result that the stars would not gravitate towards each other, thus satisfying the condition for the stability of the universe." The assumption that all the bodies of the Universe are gravitating towards each other is evidently inconsistent with the stability of the stellar bodies, each of which probably has a planetary system of its own. This does not mean that the gravitic ether has not the same modus operandi at all distances, but that the individual particles would collide with others at the end of their free paths at all possible distances between the stars, and if perfectly elastic would retrace their paths in the reverse direction. As gravitation acts inversely as the square of the distance, and as the nearest star is at least 300,000 times farther from the sun, and probably from other stars, than the earth is from the sun, gravitation between the nearest star and the earth would be only one ninety thousand millionth ($\frac{1}{90,000,000,000}$) part of the force that holds the earth in its orbit around the sun. We know that gravitation acts between these remote stellar suns and their planets: it is shown by the occlusion of light in the instance of the so-called variable stars, caused, beyond question, by a large planet interposing itself between the star and our line of vision. The phenomena of the double stars may also have a like explanation; but too little is known as yet concerning them to formulate a theory thereon. Before further considering the dynamic action of gravity it is necessary to give a short statement of the PHYSICAL CONSTITUTION OF MATTER.

All matter is believed to be composed of molecules, or groups of atoms, of a determinate character, shape and size, which, though minute, far below our power of vision aided even by any microscope, are yet vastly larger than the atoms that compose the ether.

The atoms of matter are the chemical atoms or *elements.* When combined with one another they form molecules which, with the exception of the gases, are grouped into coherent bodies having an open or cellular structure, by which the molecule, though retaining its position in the mass, can and does vibrate throughout its substance. This structure is evident from the greater or lesser elasticity of all bodies, and by the action of heat, which increases the rate of vibration and the distance between the molecules, and expands the body. This structure is called a *solid body.*

When a solid is heated to a certain temperature, that varies with its chemical composition, the vibrations increase so greatly as to overcome the cohesion of the molecules to each other (if their chemical combinations are not altered at that temperature), so that the molecules are free to move around and about each other, though the vacuities between them are not decreased, but rather are increased in size and number; in other words, the matter *melts* or becomes a *fluid.*

If the temperature is raised still higher, the molecules part entirely from each other; not only cease, absolutely, to cohere to each other, but seem to be mutually repellent, and fly away from each other; in other words, they boil and become vapors, or, if away from contact with the engendering fluid, and not surrounded by bodies cooler than their temperature of formation, they become *Permanent gases.* The temperatures at which these changes occur vary from the critical (or liquifying) point of Hydrogen—436° F. (or 24° above the Absolute Zero, when *all heat* disappears,) to that of Platinum, which melts at 3234° F., and vaporizes at a temperature somewhat higher.

The kinetic properties of a gas are as follows: A gas consists of molecules of a substance that at the existing temperature and atmospheric pressure retain their aerial condition—*i. e.,* have no tendency to assume the liquid or solid state. The molecules of which they consist have a definite size and number, being for every gas all exactly alike. The *number* of molecules in *every* gas of *any* constitution is exactly the same at the same temperature and pressure, but they vary in *weight,* or, as it is now called, in *mass,* with the weight or mass of the respective molecules, and thus constitute the *specific gravity* of the gas. These molecules are in constant, active motion, moving in straight lines in all directions, with uniform speed, until checked by some cause. These causes may be: 1st. Encounters with one another, when, each being elastic, they rebound and move again in straight lines in their new direction until a new encounter; and so, "da capo." 2d. By impinging against the walls of the containing and retaining vessel. The impact of the molecules and their momentum produces a pressure tending to force away the solid walls, which tendency is counterbalanced by the pressure of the air on the outside, if at normal atmospheric pressure, or by the rigidity and tension of the retaining walls, if the inward pressure is greater or less than the normal. The effect of these movements is that the bulk or volume of a gas of any composition is in the inverse ratio of the pressure at the same temperature. If the vessel is air-tight the bulk will diminish one-half by doubling the pressure, or will increase proportionately in volume if the confining pressure is reduced. If a gas is not restrained by confinement in a closed vessel, its molecules continue moving away in right lines indefinitely. If we apply the above statements to the gases of the atmosphere, we find that the atmosphere (which exerts a pressure of about fifteen pounds to the square inch) if viewed as of a uniform volume and density must have an average height or depth of about five miles; but, as it expands in proportion as the distance from the earth increases, being released in part from the pressure of its own mass, it probably reaches actually a height of 200 miles or more. No means are known of correctly ascertaining its limit. Its expansion may be ultimately checked by the extreme cold of the upper aerial regions, which must approximate or attain the absolute zero; it might cease then to be a gas, but would become liquid or solid; or the effect of gravitation upon the diffused molecules may overcome their dispersive motion, which may be inherent in themselves or more probably be caused by contact with the ever-moving ether atoms. It should be noticed that the normal pressure; that is, the *actual weight* of nearly fifteen pounds per square inch of the aerial molecules of the atmosphere pressing upon our bodies, is absolutely outside of and beyond our consciousness, even though the molecules, *independent of their pressure*, actually are striking us with the velocity of nearly 1500 feet per second. The pressure is uniform inside and outside throughout our frame, and, being alike in all directions, is unfelt by us. It is only when the pressure is withdrawn from one side of our hand or other portion of our body, by means of removing the air with an air-pump or other similar device, that we can realize that the weight or pressure of upwards of 30,000 to 40,000 pounds is actually distributed over our body.

In all such objective phenomena the testimony of our senses is fallacious. The revolution of the earth on its axis, when first announced, seemed opposed to our common sense, was absurd and heretical. Lord Bacon so considered it. The lapse of time has reconciled us to the thought, and it has ceased to seem strange to us; yet each true new theory goes to some extent through the same course—ridiculed at first, then decried, but ultimately accepted.

From the above description of the physics of a gas—known as the *Kynetic theory of gases*—and so fully demonstrated as to be universally accepted, the analogy between its fundamental principles and those required for the properties of the Atomic theory of the Ether are evident. The atmosphere, though composed of molecules moving in all directions with great speed and with much force, as shown by their dynamic action on the walls that confine them, yet responds as a *whole*, as an *isotropic* or a *consistent medium* or *fluid* to the vibrations of a cord, bell, or other body, and transmits the varied and complicated molar vibrations, waves, or alternate contractions and expansions that, affecting our auditory nerves, constitute musical and articulate sound.

In somewhat the same manner we may consider the transverse molar vibrations of the Ether that constitute light, heat, etc., to be the phenomena of the Ether, *considered as a consistent isotropic substance* or medium; whilst the *particles* that compose it, considered separately, are very close together, almost infinitely small, are infinitely numerous, and are moving with a swiftness greater than the waves of light, probably in the ratio that the ultimate molecules of air move swifter than the waves of sound.

To return to the hypothesis of the Atomic theory of the Ether as explaining thereby the cause of gravitation.

The atoms of the Ether are supposed to be, as before described, moving through all space equally swiftly and in all directions. A mass of matter is known to be a congeries of molecules, in which the spaces between the contiguous molecules, considered as spheres, are far greater than the space actually occupied by the molecule. This ratio between the vacuous interval and the solid molecule becomes greater in proportion as the size of the molecule is diminished. (The vortex theory of Lord Kelvin, if tenable, would, of course, enormously increase the vacuous spaces.) "Tait assumes that it is probable that the molecule itself does not occupy as much as five per cent. of the whole space." The Ether penetrates into or occupies the space between the molecules of all bodies, through which it passes owing to the extreme relative as well as the absolute smallness of its atoms, as air would pass through the interstices of a fishing net or of a sponge. The aggregate molecules of a body isolated in the Ether of interstellar space would be subjected to the concussions of the ethereal atoms moving from all directions with almost inconceivable swiftness, and with an energy proportionate to the square of the velocity of the atoms, in much the same manner as the molecules of a gas, though moving much slower, impinge upon the walls of the vessel that confines them. These concussions or impulsions thus manifesting themselves as a pressure, coming from all directions equally, would impel the material molecules of the aforesaid body, throw them into vibratory movement—if the mass were solid or liquid—and into translatory vibration, if gaseous; in all instances exerting an impulsion of the particles of the mass towards its own centre. This impulsion or pressure constitutes what we call *weight*, and is greater in direct proportion to the mass—*i. e.*, as the number of the molecules in any body kept in vibration is greater, and the motion of the ethereal atoms proportionally checked. The mass of this Earth determines therefore the proportion in which *in it* is absorbed the motive force of the Ether atoms, moving to it from any and all directions, leaving, in consequence, fewer atoms *from* the direction of the earth to oppose the motion of another and separate body. Thus, a falling stone, for instance, would find less resistance from the impulse of the atoms towards the centre of the earth, than from all other directions, and it would, therefore, move in the line of least resistance. Since the translatory motion of the Ether atoms must exceed that of light, say, 183,000 miles a second, the movement of the falling body, whatever might be its rate of *actual* motion, would be *relatively* thereto so slow that it would be, as it were, practically at rest. The impact from the Ether atoms would therefore be *sensibly constant* in their impulsive action upon the falling body, thus causing the constant accelerative rate of thirty-two feet per second of a falling body to the earth.

In thus communicating to or maintaining a vibratory movement in the molecules of matter the ethereal particles must lose a portion at least of their own motion, so that the said atoms, even if in themselves perfectly elastic, would retreat from the mass with less swiftness than they came to it; or their own motion might be entirely converted into the new molecular motions of the mass—into heat and electro static and electro motive force, in which events the ethereal atoms would come to rest; or, at least, move with the new molecular motion only. The probable farther electric action of the Ions has been already mentioned.

If two large bodies existed free to move, otherwise isolated in the Ether, but within such a distance of each other as to be within the length of the mean path of the Ether particles, their condition would be somewhat different. Each would receive as before the impact of the Ether atoms; but as there would be fewer, or possibly no atoms rebounding, or coming from the direction between the centres respectively of the two bodies, owing to the conversion in each of the ethereal into molecular action, it is evident that each body would receive more impulses from all other directions than from that towards the other body. Consequently, the masses would move in the line of least resistance, and therefore approach each other; in other words, would *gravitate* towards each other, or, if each were already moving, would revolve around each other, as the Moon and Earth do around their common centre of gravity.

It has been proved mathematically that the effect of one body thus shielding another by the interposition of their respective masses, and the absorption of the motion of the ethereal atoms into the said masses *in proportion to the molecules of the masses*, would be that the pressure forcing them together would be directly as the mass, and inversely as the square of the distance between their centres, which coincides with the Newtonian law of gravitation. When three bodies instead of two are in a straight line, as, for instance, when the Sun and Moon are on the same side of the earth, their so-called attraction upon the earth is the sum of their separate action, as practically shown by the increased height of the tides then formed—the so-called spring tides. The movement of the Ether atoms would be absorbed by each body in proportion to their mass and the square of their distance, leaving fewer in motion between their centres.

Objections may be made to the ethereal cause of gravitation, such as the possibility of excessive heat being evolved by the stoppage of the Ether atoms, and it may be asked what would be the ultimate disposal of the atoms? In reply it may be said, that there *is* the manifestation of heat in the earth below its surface, beyond the reach of solar heat radiation, the temperature increasing one degree F. for every increasing depth of 100 to 200 feet, according to location; though deep sea soundings show that the bottom water at a depth of five to six miles has only the temperature of the maximum density, about 38° to 40° F. It must be remembered that the increase of heat should be from that of the *absolute zero* (— 273° C. — 460° F.), not from our atmospheric conditions.

The ultimate disposal of the atoms and of their motion would be in causing, beside heat, the molecular motion in the mass, which all matter possesses; also the electric phenomena already described and the electric currents that give rise to Magnetism. The atoms may in part or whole continue their course as Ether atoms, and finally emerge from the ponderable body, moving as an Ether atom, but at a lower rate of motion, until ultimately brought into rapid motion again by contact with other normally swift-moving atoms.

In the study of the mechanical forces a relation is established between gravitation and other forms of energy, by the assumption that "potential force," or the *energy of position*, is possessed by a body raised to a position from which it can fall; that the body holds potentially the energy that has been exerted upon it to raise it against gravitation, and which becomes again active in its fall. This enables the calculations to be made between the motion of a falling mass and the heat produced by its fall, or the energy required to restore the mass to its former elevation. But under the Atomic Ether theory it should be looked upon as the measure of the energy expended to resist the impulsive or gravitic action of the Ether atoms. "Potential force" serves to form a "working theory," as the phlogiston theory served a useful purpose in its time, until the discovery of oxygen and the true theory of combustion displaced it. Ever since then men have wondered that so simple an explanation remained so long unknown.

The brilliant experiments of Prof. H. Hertz, of Karlsruhe, "Ueber Strahlen elektrischen Kraft (Sitzensberichte der K. Preussenischen Akademie der Wissenschaften," Dec., 1888), have established the identity of the movements of the electric waves with those of light; or, as Hertz modestly stated: "It seems to me that the above described experiments must serve to a great degree to remove all doubt as to the identity of light, radiant heat and electro-dynamical wave movements." They also prove the existence of the Ether in which they have their being, whatever may be its constitution, beyond the possibility of farther dispute. The radiant Magneto-Electric waves are of great length and relatively very slow. They are the source of the waves used in Wireless Telegraphy. Many have thought that Gravitation depended in some way on Electricity, but *it* is a phenomenon of the Ether—still unexplained.

The Law of Parsimony in Philosophy should lead to the acceptance of the atomic theory of the Ether as the probable cause of gravitation; at least, until a better and more satisfactory solution of the problem can be suggested. It is, moreover, the only theory that is plausible, or even possible, so far as known. It should be borne in mind that it was long after Newton's time that the difficulties in his theories of light and of the laws of gravitation were reconciled; that the erroneous views that even he held were corrected and the truth of his main laws established, and it may so prove in this case. Thus the determination of the problem, "What is Gravity?" has not yet received a generally accepted answer. That it is the result of molecular movement in the Ether is more than probable—it is almost a certainty; but as Newton delayed the acceptance by his own mind of the operation of the laws of gravitation until the actual diameter of the earth was truly ascertained, corrected the apparent discrepancy in the calculations of the moon's orbit, and finally established the truth of his theories, so must the "Nature of Gravity" wait for further knowledge before it can be finally removed from the realm of occult causes, and brought within the comprehension of the human reason. Until this is done the doctrine of the correlation of forces is incomplete, and the action of gravity remains as an unexplained anomaly in our philosophy.

CHAPTER XIII

CONSTITUTION OF MATTER—CHEMISTRY—THE ELEMENTS—PHLOGISTON THEORY—OXYGEN AND COMBUSTION.

In the short sketch given of the history of Alchemy it was noticed that this pseudo-science, vain in its purpose and futile in its ends, had yet enriched the world with many discoveries of the properties of matter that otherwise would long have remained unknown. This knowledge, though, was a heterogeneous mass of disconnected, unsystematized facts, imperfectly understood, and filled with mistakes and errors. The idea that the base of all substances was one—the formless matter, inert and without properties; in itself ignoble and of degrading nature, unworthy of study or examination—was universally held. It still exists, often unconsciously, in the minds of many metaphysicians and theologians. The word "Materialistic" is still a term of opprobrium. The four elements—earth, water, air and fire—were thought to be the cause of the "accidents of the substance to which its respective properties were attributed, and the change of one of the four elements for another could give rise to quite another body.

Robert Boyle (1627–1691) was the first to deny that the composition of matter was dependent either on the four elements above named or upon the Sulphur and Mercury of Paracelsus, and to suggest that "all substances that could not be chemically separated into other constituents were elements." This definition of an *element* is adhered to at the present day. Boyle maintained that Chemistry should be studied not only for its uses in alchemy or in pharmacy, but for its own sake, as a branch of Natural Science. He should be considered as the Father of Chemistry viewed as a true Science.

The next great forward step was Stahl's (1660–1734) Phlogiston theory, which, although entirely erroneous, and ultimately abandoned, served a useful purpose in holding together for the time facts that were otherwise disconnected, and in affording a working hypothesis, until greater progress disclosed its errors and submitted the true theory of combustion in place of the erroneous one.

Stahl's theory was, that combustion was caused by the combustible substance parting with its *Phlogiston*, which was thought to be a constituent of such bodies, the phlogiston escaping in the shape of flame; in the case of a metallic body leaving behind either a calx, an acid, an earth or ash-like substance, which was supposed to be the really pure substance. When the latter was united with phlogiston it formed the metal, the sulphur, or other combustible. Sulphur, for instance, being the compound of sulphuric acid and phlogiston, etc. The phlogiston, when escaping into the air, was absorbed by plants and animals, either directly or indirectly, and became the source of heat and life to man. It was soon found that a metal when burned, Mercury, for instance, yielded a calx (an oxide) that weighed *more* than the metal and phlogiston did originally. This was accounted for by attributing negative gravity, or a principle of lightness or levity, to the phlogiston, and found support in the fact that the flame from burning matter ascended in the air. Absurd as this theory now seems to us, it commanded general assent for many years, and retained its adherents even after the discovery of oxygen and the true phenomena of combustion.

In 1755 Joseph Black (1728–1799), of Edinburgh, described the preparation of "fixed air," or carbon dioxide. Until this time all gases were looked upon as being identical with air. No difference in nature or properties were known to exist. Black showed that the gas obtained by heating Carbonate of Magnesia was the same as that produced in combustion, in breathing, and in the fermentation of beer, and had properties entirely different from those of atmospheric air, being what was known heretofore as "fixed air."

Joseph Priestley (1733–1804) pursued these investigations into the nature of gases and into the composition of the atmosphere. He found that when charcoal was burned in a closed vessel containing air, and the fixed air thus produced was then absorbed by lime water, the volume of the air was diminished by one-fifth, and the remaining four-fifths were no longer capable of supporting combustion or respiration. This remainder he considered to be phlogisticated air, since it had no longer an affinity for phlogiston. In 1774, by heating the red oxide of Mercury (the "Hydragyrum precipitatum per se" of the Alchemists), he obtained a gas which he thought was entirely free from phlogiston; it eminently supported combustion. He considered it to be dephlogisticated air. This was the all-important discovery of oxygen. It is well worthy of notice that neither Priestley, Cavendish nor Scheele, each of whom occupied himself with and extended his investigations into the properties of oxygen, ever gave up the phlogiston doctrine, or accepted the true philosophy of combustion.

This shows how difficult it is to displace erroneous views from the minds of men, who have found therein a satisfactory explanation of the facts as they were then known, even when they themselves have furnished the new facts that established another theory, irresistible to minds that were free from the bias of earlier convictions.

Notwithstanding the known existence of Oxygen, the nature of combustion remained thus misunderstood until **Antoine Laurent Lavoisier** (1743–1794) announced his theory thereof. In 1777 he gave to the Academie des Sciences his memoire on "Some substances that are constantly in the state of aeriform fluids at the normal temperature and pressure of the atmosphere." This was the first study of the distinctive nature of gases. This was followed in the same year by his paper on "The constitutive principle of heat known as Caloric." In the above, as well as in the number of later contributions to the Academie, he expounded his theory of combustion, which taught that "A body can burn only in air holding oxygen (pure air)." By combustion, light and heat—which were thought to be *substances*, but imponderable—became free, whereby the Oxygen that had been previously with the Caloric was consumed; the air thus losing in weight as much as the burning body gained, and, that the latter, by its union with oxygen, formed an acid, or, if a metal, a metallic calx. He also recognized the role that oxygen plays in respiration, whereby the blood in uniting therewith is in part consumed; the constituents of which must be restored later by the nourishment taken. He agreed with Boyle that only the substances capable of demonstration, and that could not be further separated into their own constituents, should be considered as elementary. To Lavoisier is also due, in common with Guyton de Morveau,* the establishment of the new chemical nomenclature. It replaced the strange and often absurd names inherited generally from the language of Alchemy, by a clear, simple and distinctive terminology, that usually carried its definition in its name.

In 1789 appeared Lavoisier's "Traite Elementaire de Chimie," in which the new views of the science were set forth in the most admirable and convincing manner. The plates explaining the apparatus he had contrived for his experiments were drawn and engraved by his Wife, who, Cuvier states, "had understood and seconded him in his labors, and whose precious qualities were the charm of his life."

Lavoisier commenced in 1793 to gather together his memoirs, which were scattered through the records of the Academie for over twenty years, and to arrange them consecutively, according to the nature of his discoveries. Four of the volumes were each partly printed, when he was arrested as one of the "Fermieres Generaux," or Revenue Commissioners, by the revolutionary tribunal, and, although the administration of his duties in the collection of the national finances had not only been without blemish, but of singular advantage to those within his charge, he was guillotined with twenty-eight other "Farmers General" May 8, 1794. He asked for a delay of several days, in order that he might complete for the benefit of humanity the arrangement of his memoires, but the Chief of the horrible tribunal savagely replied: "We have no use for Savants." Lavoisier was only fifty-one years old. What discoveries might he not have made had he lived longer! As Lagrange truly said: "It only required one moment for the executioner to cut off such a head; but centuries may roll by before another like it is produced."

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*1737–1816. The discoverer of the destruction of Typhus Fever, of Jail fever germs, by sulphur and chlorine fumigation.

CHAPTER XIV

THE ATOMIC THEORY OF MATTER—JOHN DALTON'S LAW OF DEFINITE PROPORTIONS—THE INDESTRUCTIBILITY OF THE ATOMS — MOLECULAR FORMATIONS — CRYSTALLIZATION.

WE have had occasion several times, in speaking of the views held of the physical nature of matter both by the ancient writers and among modern ones, to refer to the atoms, and to the theories in which they played an important part. In all of the above instances they were supposed to be of one and the same nature; the use made of them required them to be solid, hard, elastic and imperishable; but nothing had been shown that required these atoms of matter to be essentially different one from the other, or from the negative qualities that the ideas of Democritus, Lucretius, or even the Aristotelian conception of the Scholastics had formulated. When Boyle, and later when Lavoisier, had recognized the existence of various elements, new ideas arose. The use of an accurate balance in the examination of substances showed that definite relations existed between the weights of the constituent elements.

Charles Frederic Wenzel (1740–1793) found that the amount of basic oxides required to form neutral salts with a given acid was proportional to the weight of the oxides required to saturate one and the same amount of another acid. These results he published in 1777. The law of definite and multiple combinations was not, however, finally and indisputably established until the publication of Dalton's Atomic Theory of Chemistry reduced to order and simplicity the previously disconnected and unexplained phenomena of chemical combination.

John Dalton (1766–1844), mathematician, physicist and chemist, was the son of a weaver of woolens, in very poor circumstances, at Eaglesfield, in Cumberlandshire, England. He and his parents belonged to the Society of Friends. He was sent to a school near his home, kept by one of his own sect, at an early age. When the boy was less than twelve years old his teacher told his father that he could teach him nothing more, and urged him to send him where his rare abilities could receive the benefits of a University culture. This his father could not do; he was obliged to keep him at home to assist him in his work. For two years he thus remained, and, in order to retain what he had learned, he taught in the winter evenings at a school composed of his former associates, all older than himself, as much as he had been able to learn. When he was fifteen, he was called to Kendal by a cousin who had a school there, and placed as second in charge thereof. Here he acquired knowledge of the Latin and Greek authors of antiquity. In Kendal resided a Mr. Gough, a man of fortune and of distinction, who, although blind, was devoted to scientific study, and lived surrounded by his books and philosophical apparatus. Under his instruction, and by assisting in his experiments, Dalton acquired that taste and power for the observation of the facts of natural science that led to the discoveries that have immortalized him. This intimate connection between them lasted eight years. In 1793 the town of Manchester founded a College, and applied to Mr. Gough for a Professor for the Chair of Mathematics, and Dalton was appointed to it. Among his first contributions to science was a paper upon the "Vision of Colors," in which he described an aberration of sight, color blindness, from which he suffered. He could not distinguish between red, purple and blue. This affection of sight has since been known as "Daltonism." He thought this condition was due to the color of the fluids in his eyes. By his direction, his eyes were examined after death, and the crystalline lenses were found to be slightly yellow; but, nevertheless, on trial, objects viewed through the same appeared to preserve their natural color.

Dalton devoted his life to the study of natural phenomena. He made more than 200,000 observations on the conditions of the atmosphere; he determined conditions existing between rain and the dew; the degree of heat and cold produced by condensation of the air, and many other meteorological investigations.

In 1801 he suggested the probability that all gases could be reduced to the liquid state under suitable conditions of low temperature and strong pressure. The last few years has proved the truth of his surmise; all the gases have been liquified and all solidified. In 1801 Dalton published his "New System of Chemical Philosophy," in which he showed that the elementary substances consisted of atoms, peculiar to each element, that united with the atoms of the other elements in exact and definite proportions; that these ratios were constant and absolute for each substance; the elements uniting with each other only in these proportions, or, in some instances, in a simple multiple thereof. To each of the simple elements, or the atoms thereof, he assigned a certain relative weight, for which he assumed the weight of an atom of hydrogen (that element having the lowest combining number known) as unity, all the other elements being simple multiples thereof. The elements, when uniting with each other and forming new compounds, did so only in the ratio of these combining numbers. If a greater proportion of either of the constituent elements were present than formed these ratios, the excess thereof remained unaffected and unchanged. The number of these elements then known (1810) were about forty-five, though some of them as yet existed only as oxides, or otherwise in combination. This theory, like most new ones, met with many opponents, but he lived to see its general acceptance. Dalton never married. He said "he never had time to get married." He died July 27, 1844.

Modern Science has grouped the atoms of Dalton into two classes of molecules. One formed from the union of two or more atoms of the same elementary nature, but constituting a body with other properties than those of the single atoms—such as the union of three oxygen atoms to form one of ozone; the other from the union of two or more dissimilar elementary atoms into like groups. Thus the two atoms of Hydrogen and one of Oxygen form one molecule of water. Generally speaking, the new body thus formed possesses no analogy to the properties of its constituents.

The labors of Berzelius, Gay-Lussac, Avogadro and Ampere established the facts that the number of molecules in equal volumes of all gases are the same. This served as the points of departure for the discovery of the relation between the gaseous state and volume of the elements, and their chemical and atomic relations, that in the last forty years have changed the nomenclature as well as the theories of chemical affinities. The various systems by which it was shown that the molecules were grouped—viz: the Dualistic, the theory of Radicals, the Substitution theory of Gerhardt and Laurent, and Gerhardt's theory of types—each contributed in turn to the advance of science, being complemented finally in the theory of the Valences of the elements. By this it is shown how chemical combinations are formed; new molecular groups with their distinctive properties may be predicated, and at the same time it is made evident why the atoms cannot enter into every desired combination, and why certain grouping of molecules must be impossible.

Of the cause, or rather of the nature of chemical affinity, we have no conception. We know that certain elements or molecules have the quality of uniting with certain other molecules with great energy; that they displace other molecules to do so; but what this affinity is, we know not.

The combinations of atoms into molecules, or the affinities of chemical attraction, at least as we know them, seem to exist only within a very limited range of temperature. At low temperatures—such as that at which the atmospheric air liquifies (312 degrees below zero F.)—chemical action almost ceases. Even Fluorine, which ordinarily acts so energetically upon all other substances as nearly to deserve the name of the Alkahest or universal solvent—the material sought for by the Alchemists of old—is without action upon all bodies, excepting Hydrogen and some of its organic compounds. Probably even this action would cease with still greater cold. At a very high temperature, such as a white heat, most inorganic compounds are dissociated into their component atoms. To effect many changes of affinities it is necessary to raise the respective molecules to a higher temperature than that normally existing, when the increase of heat alters the pre-existing affinities. No change in chemical composition takes place without a simultaneous evolution or absorption of heat, a manifestation of electrical phenomena, or of both phenomena.

When the change in the combination of the molecules begins, it is often attended with so great a development of heat as to raise the surrounding molecules to great activity, and to propagate the action throughout the mass of the molecules in contact.

This, in the union of carbon, hydrogen or the compounds thereof with oxygen or atmospheric air, constitutes the phenomenon of ordinary combustion. The respiration of animals is of the same nature. The carbon and hydrogen constituents of the blood are brought in contact in the lungs with oxygen and converted into Carbon-Dioxide and water. Heat being evolved to the same extent, but not with the same intensity as in ordinary combustion. When the molecules of the one body are surrounded by, but not mixed with, the molecules of the other, the chemical action being limited to the surface only of one of the bodies, the change in combination is gradual, proceeds slowly and without violence. If, on the contrary, such molecules are intimately mixed together, as coal gas when mixed with air, or if oxygen is held in such a combination that a slight rise in temperature will set it free, as it is in the saltpetre contained in gunpowder, the chemical action is transmitted almost instantly throughout the mass, causing a violent and destructive explosion, with intense heat and consequent expansion of the gases formed, into many hundred times the bulk of the pre-existent masses.

The many myriads of substances—solid, liquid or gaseous, mineral or organic, inanimate or having life—that are met with in this world, and we have reason to believe in the thousands and millions of other worlds, shown to us by the stars in the heavens around us, all are composed of the grouping together into molecules of two or more of the atoms of about sixty-eight different elements. Of these, fifty are metals, one-half of them so rarely met with that even most professional chemists have never seen them or their compounds. In the inanimate world that we are familiar with, not over twenty-five enter into its composition. In the living animal or vegetable world still fewer—only about fifteen—are ever present. It is very seldom that even one-half of this number occur.

In regard to the compounds constituting the inorganic world we may be said to have a pretty accurate knowledge of all that form the outer crust thereof, though we may find and do find from year to year some rare substance that we cannot prove to be composed entirely of the known elements, or that contains some substance with new properties that we cannot separate into still simpler atoms. This distinction of properties between the elementary atoms of one body and those of another is absolute and invariable. The atoms of each *one* kind are absolutely the same, unchangeable and indestructible. It is impossible to create them by human means, and it is impossible to destroy them. Each atom may group itself with others like itself to form molecules of solid, liquid or gaseous bodies (according to the degree of heat present), or one atom may form with one or more dissimilar atoms, other molecular bodies of like variable physical conditions; but in all combinations whatever, the mass of the new body or bodies formed are the exact sum of the simple atoms that pre-existed. When bodies are separated, decomposed or apparently destroyed by fire or otherwise, the atoms, if collected, whether singly or in the shape of new combinations, will exactly equal in the aggregate the weight of those that constituted the former and original substances. Matter is indestructible. It cannot be created, nor can it be destroyed.

When a solid, inorganic substance is slowly formed, either from the slow condensation of a vapor into a solid; by the cooling or the evaporation of a solution of a solid; or, finally, by the cooling of a mass brought into the liquid state by fusion, it is usually found that the solid thus produced possesses definite form. The sides, or plane surfaces, and angles uniting them are definite, constant and peculiar to the particular substance in question. This is the phenomenon of crystallization. In a few instances the substance possesses polymorphism; that is, it crystallizes in two or more forms not belonging to the same system. This seems to be dependent upon varying conditions of temperature in its formation, or on the presence of foreign salts. On the other hand, instances of isomorphism are not rare where different crystals, having their sides and angles nearly or quite equal one with another, yet differ in their chemical constitution. Generally, however, the crystaline formation is a true index to the chemical composition. The same characteristics apply to many substances, derivates of organic structure. The deviation produced by certain crystals—Iceland Spar, Tourmaline, etc.—upon a ray of light has already been noticed. The closest relations exist between the main geometrical axis of many crystals, the optic axis of refraction and the transmission of heat, light and magnetism. Whether these relations depend upon the properties of the Ether, upon the chemical affinities of the atoms therein, or solely upon the geometrical form and construction of the crystal, are as yet unsolved problems.

CHAPTER XV

ACTION OF CHEMICAL AFFINITY—GALVANIC ACTION — MAGNETISM — ELECTRICITY — KATHODE AND RÖNTGEN RAYS—PERSISTENCE OF ENERGY —SOLAR HEAT, THE SOURCE OF ALL ENERGY— ORIGIN OF SOLAR HEAT—ACTION OF THE ETHER —DISSIPATION OF ENERGY—ENTROPY.

THE phenomena of chemical affinities may manifest themselves in different ways. Apart from the effect produced upon a single elementary substance by the action of heat, light, or electricity, such as the fusion of a metal, the development of magnetism in iron by an electric current, or the phosphorescence of certain substances after exposure to light—which are rather physical than chemical phenomena—nearly all chemical changes of combination are caused by variations in the action of the above-named forces. These alterations in affinities may be:

1st. Simple disruption of the molecules, as when oxide of mercury is resolved by heat into mercury and oxygen.

2d. The simple union of the atoms or molecules of two elements, as when sulphur and iron when heated form iron sulphide.

3d. Decomposition by substitution. When to a substance composed of two or more different atoms or molecules the molecules of a third substance are brought, whose affinities for one of the constituent molecules of the first substance is stronger than that existing between the molecules already in combination, then the third element will displace one of the former, setting it free. Thus zinc, when added to hydrochloric acid (a compound of chlorine and hydrogen), will unite with the chlorine, forming Zinc Chloride, displacing the hydrogen, which escapes in the free state.

4th. Double decomposition. When to a substance composed of the union of two different molecules is added another substance whose two component molecules have stronger affinities for those that compose the former body, there will be formed new bodies from the mutual interchange of the molecules respectively of the two original substances. For instance, when a solution of silver nitrate is brought into contact with a solution of sodium chloride, the result is the formation of sodium nitrate and the precipitation of the insoluble Silver Chloride.

As already stated, the changes of chemical affinity are accompanied or caused by the manifestation of heat and electricity. This is especially the case with the action described under (2) and (3). In a similar manner chemical changes are dependent usually upon the action of heat and electricity. These relations and the nature of chemical affinity may be to some extent explained as follows:

"The atoms of all ponderable matter are in constant motion. Upon the rapidity and extent of this motion depend its physical condition, whether it is to be solid, liquid, or gaseous. Every force which alters the vibrations of the atom must also change the properties of the matter, since these properties depend upon the movement of the atoms. Besides ponderable matter, there exists the imponderable ether, whose atoms are in continuous motion and whose vibrations produce the phenomena of heat, light and electricity. These vibrations can transplant themselves as such into the atoms of ponderable matter, and thereby cause a change in the nature of the molecules, thus producing chemical action. For instance, when light falls upon Silver Chloride, the latter becomes black, and a part of the light as such, disappears. This is because the rapid vibrations of the Ether are transformed into slower vibrations which they share with those of the material atom, and which manifests itself by the decomposition of the Silver Chloride. In other instances, the character of the vibration, whether that of electricity or heat, will alter the condition of the vibrating atomic combination. This action may express itself as change of temperature, change of state of aggregation, or as chemical changes. The phenomena are always the consequence of an increase or diminution of the active energy of the ponderable atoms, which corresponds to a diminution or to an increase of the active energy of the ethereal motions. Like alterations of movement occur in the chemical processes of combination and of double decomposition, which are produced by the force of affinity; that is, by the effort of heterogeneous atoms to carry out their vibrations in accord with each other. The alterations in the active force of the material atom must correspond to those of the active force of the ethereal atoms. Usually this alteration manifests itself as the development or absorbtion of heat. Thus it follows that a *chemical* reaction is analagous in its abstract nature to a change in the *physical* state of aggregation in the molecules of a body."*

CHEMICAL ACTION is effective at very small distances only. The molecules must be in actual contact, or no changes of affinities are manifested. When a plate of Zinc is placed in a dilute solution of Sulphuric or other mineral acid, a lively effervescence occurs. The Zinc dissolves in the acid, the solution grows warm, and Hydrogen gas is freely evolved from the Zinc surface, causing the effervescence. If the Zinc plate be connected by wire, in or outside of the liquid, to a Copper plate immersed in the same solution, but the plates not in contact, it will be found that the gas will no longer be evolved from the Zinc plate, but will be from the Copper one. The Zinc plate nevertheless, will dissolve more rapidly; the Copper plate will suffer no loss or change; but will be found charged with *positive electricity.* If the wire be cut in the middle and the ends kept apart, the prior existing conditions will return. On bringing again the freshly cut ends together, when nearly in contact a spark may be seen to pass from one to the other. The condition will be again reversed, and the characteristics of the Electric current are manifested. This constitutes the simplest form of the voltaic battery. By examination it is found that for every molecule of Zinc dissolved a constant quantity of Electricity is produced, which in its turn can be converted into equally constant degrees or quantities of heat, of light, of mechanical motion, or be made use of to effect the decomposition of metallic salts in solution that will be alike constant in the amount thus decomposed. If the process be reversed and a current of electricity, however produced, be transmitted to metallic plates or objects connected as described, and immersed in a solution of metallic salts, copper or silver salts for instance, the salt will be decomposed and the metal deposited upon the surface of the object attached to the Kathode or negative pole, plate, or wire corresponding to the Zinc elements of the battery—a copper plate, if a copper or silver salt be used, constituting the anode, the opposite or positive pole. Thus also the chemical action between the metal and acid may be used for producing light or heat by the electric current, or it may be used for causing magnetic attraction between the poles of the electro-magnet and its armature in a Dynamo, thus giving rise to mechanical motion. Mechanical motion again in its turn, when applied to a dynamo, generates magneto-electric currents that will produce chemical combinations or decompositions, heat, light, and all the other phenomena above-named.

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*Pierer's Kon. Lex. B. 3. S. 930.

The phenomena of Magnetism—undoubtedly one of the forms of Electricity and of the ethereal medium —are yet very imperfectly understood. The natural Magnet, the Lodestone, early attracted attention. Plato thus speaks of it: "A divine power, which moves you, like that in the stone which Euripides calls the Magnesian, but the common people Heraclean. For this stone not only attracts iron rings, but it imparts a power to the rings, so that they are able to do the very same things that the stone does, and to attract other rings and sometimes a very long series of iron rings hung one from another; but from that stone depends the power in all of them." (Plato's Ion., Sec. 5.)

The stone thus described is essentially one form of the Black Oxide of Iron ($Fe. O. Fe_2O_3$), the magnetic iron ore of the Iron Masters. It was early known that the Lodestone could confer properties like its own upon rods or strips of steel by being drawn thereover frequently in one direction. After which the rods would show polarity. If hung horizontally so as to turn readily, the same end would always point towards the North. The Chinese noticed the phenomenon, and used the Magnet in navigation many centuries before the Europeans invented the Mariner's Compass. The property of polarization referred to above is due to the fact that the globe of the earth is influenced by thermo-electric currents, induced by its diurnal revolution and consequent variation of temperature, and also by other causes. These currents flow in lines parallel to the Equator. A magnet when within an electric field will always place itself, if at liberty to move, at right angles to the direction of the flow of the current, thus causing the positive pole of the magnet to point towards the North in a natural terrestrial magnetic field. An electric field or current such as described surrounds a magnet, and will convert another piece or rod of iron into a magnet if placed in proper contact therewith. If the iron is soft—that is, *pure*—the magnetism will continue in it only so long as they are in electric contact; but if the iron is *hard*—that is, if it, like hardened steel, contains a small amount of chemically combined Carbon, and the contact be maintained for some time—the steel-like iron, will acquire permanent magnetism equal to the original magnet, though the latter will lose none of its own.

If an electric current from any source is caused to pass through an insulating-covered wire (a conductor), making many spiral coils around a rod or other mass of iron, the iron, if soft and pure, will become a strong magnet, but will lose its magnetism instantly on interruption of the electric flow. On this property depends to a great extent the application of electricity to the dynamo, the telegraph and most of its other uses. If steel or hard iron is used in place of soft iron, it will acquire permanent magnetism. It is thus that magnets now are practically made. How or why the Black oxide of iron and why hard iron should possess this strange power of retaining magnetism permanently, themselves undergoing no chemical or physical change, is inexplicable. Within the last twenty years the application of Electricity and of electro-magnetism to new and important uses have been so numerous as nearly to revolutionize the procedures of our daily life. They far surpass any corresponding advance in our theories or knowledge of the nature of Electricity itself. Very little has been discovered therein beyond Hertz's corroboration of Maxwell's ideas as to the non-instantaneous transference of electric and magnetic forces, and the establishment of the identity of the phenomena of radiant light and electricity; the waves of the latter, or the electric vibrations of the Ether that transmit them, substantially agreeing in rapidity of transference through space, in reflection by a suitable mirror, in being dispersed by a prism and in becoming polarized, with the similar phenomena of light waves; differing only in the much greater length and slower movements of the waves of electricity.

The importance of the practical adaption of electromagnetism to the dynamic motor; its use in the telegraph and the telephone, are well known, but the details thereof are not within the scope of this writing. The *late and interesting discovery* of the strange properties of the so-called *X-rays, or the Röntgen rays*, and of the closely related *Kathode rays* require that they should be noticed.

The generating vessel of the Kathode rays and of the Röntgen or X-rays consists of a glass tube or bulb—the so-called Crooks' tube—into each of the opposite ends of which a platinum wire is inserted by the fusion of the glass. Means are provided whereby the air or other gas contained therein can be exhausted to any desired extent; if absolutely exhausted, no electric current will pass. When the above-named wires are connected with the terminals of a Ruhmkorf's or induction coil, whereby the rapid alternating currents of magneto-electricity are produced, electric sparks will pass through the partially exhausted tube so frequently as to appear like a constant stream. The wire by which the current enters—the Anode—bears on its inner end a small concave Platinum disk. The opposite wire—the Kathode—bears either a similar disk or, if producing the Röntgen rays (the X-rays), a small, flat plate, inclined at about an angle of forty-five degrees toward one side of the tube. When the aerial contents of the tube are so far exhausted that only about one-millionth thereof remains, and the alternating secondary electric current is passed, the rosy light that first appears between the electrodes gradually retreats towards the Anode and finally disappears, whilst from the Kathode, the negative pole, a pale, bluish light spreads in increasing volume, and finally, though but faintly visible, fills the whole tube. These Kathode rays pass in straight lines perpendicularly from the surface of the Kathode plate without regard to the relative position of the two poles. They can be deflected by a magnet—bent out of their course. When the Kathode rays fall upon the glass walls of the tube they excite the glass to a vivid, yellowish-green glow, but do not seem to escape from the tube.

In 1895 Röntgen found that when he brought fluorescent substances, though enclosed in thick pasteboard cases, near the tube they would glow with a phosphorent light, though no light from the tube itself was apparent. These invisible rays seemed to radiate from a certain part of the yellowish-green lighted surface. They were not Kathode rays, for they had not the characteristic property of being attracted by the Magnet. For these new rays, that Röntgen provisionally called X-rays (unknown rays), all bodies are more or less transparent. They will pass through a thick book of 1000 pages, through thick blocks of wood, and even through metallic plates, if not too thick. The permeability of plates seems somewhat dependent inversely upon their specific gravity. A plate of lead $\frac{1}{16}$ inches thick is nearly impenetrable, while one of aluminum ten times as thick is penetrated. The X-rays are neither reflected nor refracted. The Röntgen rays, invisible themselves, cast the shadows of difficultly, penetrable bodies permanently upon the photographic plate, or, if falling upon a fluorescent substance, produce visible shadows thereon of the dense body that cut off their rays, the said rays passing almost unhindered through the thick soft tissues that lie between. In either case they render information and help to the Surgeon from unexpected and unknown sources that would have seemed like the fairy tale of a magician's power, if told of or predicted a few years ago.

The properties of the Röntgen rays are involved in those of the Kathode rays, for before escaping through the glass tube they were part thereof. The rays emitted from the Kathode consist of a mixture of varied nature. The larger part, those which become visible by impinging on the side of the tube, are stopped in their course by the walls thereof, which they heat by their impact; they are deflected by a magnet. They are emitted at right angles, perpendicularly to the surface of the Kathode plate. If it is deeply concave, they can be brought to a focus therein, where they will develop intense heat, and will even fuse Iridium, the most intractable of metals. They are not permeable to glass, but will pass through a thin plate of aluminum if forming a part of the tube wall; will escape into the air and there show a diffused light. They are thought to carry material corpuscles negatively electrified. They appear to be of the identically *same character* irrespective of the *nature of the gas* in the tube from which they originally came.

J. J. Thompson and other investigators suggest that they may be atoms of primordial stuff, or particles broken off from physical atoms. He estimates them to be excessively small—about $3/10^{-28}$ of a gramme in mass (about three quadrillions, or 3-one million million million millionths of a gramme)—or about the one thousandth part of the size of an atom of Hydrogen. They have a translatory velocity of 40,000 kilometers a second (about 25,000 miles a second), rather less than one-seventh that of light.* Their character, size and velocities approximate those required for the molecules, or the Ions, in the theory of the Atomic structure of the Ether. It is, moreover, opposed to all the known facts and established theories of Chemistry, to admit the *possibility of Atoms being broken.* The Ether is undoubtedly connected with its phenomena, but it is not generally accepted as an explanation thereof, though maintained by some—preference being generally given to the view above stated, *i. e.*, that they are negatively electrified corpuscles of material atoms. Of the rays that have passed through the sides of the glass tubes (the Röntgen rays), thus separated from the other components of the Kathode rays, even less is known as to their actual nature. The important service that they have rendered mankind is far in advance of any plausible theory of their nature.

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* Estimated now (1902) to be about half that of Light.

The extraordinary properties possessed by the native ores of Uranium, its salts, and possibly some new elements that are associated therewith, offer phenomena that are unexplainable. They emit spontaneously and continuously phosphorescent rays in many ways similar to the Kathode rays. They blacken the sensitized photographic plate; possess the power of fluorescence and of penetrating through solid matter, though in a less degree than that of the Röntgen rays. No discoverable chemical change in their composition and no apparent loss of weight has been detected. The are in every way an anomaly. It may be that Uranium, and possibly some element associated therewith in its native ores, possess as extraordinary relations to radiant light, apart from all changes in chemical constitution, as metallic iron does in respect to electricity. Though long acquaintance has made us familiar with the phenomena of permanent magnetism in a Horseshoe or other Magnet, yet the cause thereof is unexplainable.

As science has established the doctrine of the indestructibility of matter, so it has demonstrated the indestructibility of energy. No human power can create it, nor can human means destroy it. The permanence of energy and the correlation of forces have ceased to be theories. They are now the axioms upon which our philosophy is built, and the foundation upon which knowledge and science rest. By their help only can the Path of Evolution ever be more fully known. These results have been obtained, not through deductive reasoning from a-priori ideas or assumed premises, but by careful observation and repeated experiment. They have shown that when any form of energy, such as the motion of translation of a mass of molecular matter, or when that motion which constitutes heat, light, electricity or chemical action disappears, it is not lost, but reappears in one or more other forms, bearing an exact and definite ratio to the quantity of the force expended. Thus, when a mass of 772 pounds falls to the earth from the height of one foot, its arrest evolves as much heat as would raise the temperature of one pound of water one degree F.; conversely, one pound of water in falling one degree in temperature will give off heat enough to raise 772 pounds one foot high. This relation of heat, height and weight is used as the *constant* under the name of "foot-pounds" with which to measure not only heat, weight and motion, but also as the standard with which to compare all other changes of energy.

It has been shown that all energy, or the manifestation of all physical force on the globe is derived directly or indirectly from the radiation of heat and of light from the sun. All physical motion, for instance, the force of falling water is due to the evaporation by solar heat of water from the ocean and its precipitation again as rain upon elevated ground, whence it flows or falls to a lower level; the action of the wind is caused by the ascension of heated air; the power of steam is obtained by the combustion of coal or wood, the carbon of which in early or in later times was stored up by the living leaves of trees, that solely, under the influence of the *sunlight,* absorbed and decomposed the Carbon Dioxide of the atmosphere; the muscular force of animal strength, that obtained its energy likewise through the vegetative growth, under the sun's light, that gave the animal its food. Chemical action itself is dependent upon a certain degree of warmth, below which all change of affinity ceases. Even life in all its forms is only possible when the light of day and the heat thereof provides those conditions that are essential to the organic growth.

All the phenomena that nature presents are thus the manifestations of *one power*, brought to the earth by the Ether; it is uncreatable by man and by him indestructible. Protean in its form, in its essence it is inscrutable and unknown. Including within itself, as it must do, the mysterious energy of Gravitation, of which we know the laws of its action, but not yet surely its cause, it binds the inorganic Universe into one whole, one macrocosm, revealing to our sense of sight on the one hand, the intimate structure of all organic bodies by means of the microscope, though not the atoms or even the molecules of ultimate matter; while, on the other hand, it teaches us that there are innumerable worlds governed apparently by the same physical laws as our own world, but almost infinitely distant. As Proctor has said of the stars: "Beyond the limits of the highest power of the telescope lie thousands of millions more."

The vibrations of the material atoms of the sun transmit to us through the vibrations of the ether the energy of light, of heat, and of elecricity; but what causes the vibrations of the atoms composing the sun's matter? The photosphere is evidently intensely hot; but whence arises the heat? Combustion, or the results of chemical action, has been shown by calculation to be utterly inadequate to produce and maintain its emission of heat. "If the whole mass of the sun was composed of coal, it would all be consumed in 6000 years." (Barker.)

The conversion of the motion of aerolites into heat by their fall into and impact upon the sun probably contributes a small but an insignificant and inadequate portion. The generally accepted theory is, that the solar heat is due to the *condensation* of the originally diffused nebulous matter of the sun's mass upon itself, under the influence of gravitation. Be the cause of gravitation what it may—the impact of the ethereal atoms upon the molecules of matter or some other unknown force—the heated gases and metallic vapors now constituting the atmosphere and outer portions of the sun, must be driven back towards the centre of the sun as the molecules of our atmosphere are driven back by the same or other cause of gravitation, and prevented from passing out and being lost in space. The heat of the sun caused by and persisting since the condensation of the original nebulous or disseminated state is augmented by the continued condensation of the molecular mass, and returns to the ether in the shape of the *molar vibratory* motions of heat, light and electricity in the Ether as an *isotropic medium*, that energy which its individual atoms before exhibited in their inherent atomic motion, and expended in the condensation of the sun's molecules by the arrest of their own movement.

There are evident reasons why gravitation or the arrest of the motion of the Ether atoms should here manifest itself principally as heat. The sun is the central body of the Solar System, by far exceeding the combined mass of all its planets; it has, so far as known, no other motion than around the common centre of gravity of itself and the planets, with the rotative motion on its own axis, which motion, as well as any translatory motion in a straight line that it may have, would, according to the laws of Inertia, require no expenditure of energy or maintaining force. The planets and their satellites, on the contrary, are continually deflected from their normal right line motion by the force of gravitation, or the impact of the ethereal atoms, which, in the instance of this earth, is a force sufficient to deflect the mass of the earth from a straight line into the curve of its orbit. The equivalent amount of energy expended on the sun, though divided proportionally between the planets and the sun in the ratio of their respective masses, would manifest itself in the sun as heat only, since the common centre of gravity of the sun and the planets is within the body of the sun itself; the latter having, so far as known, no orbital motion. It is certain that a large part of the Sun—the photosphere—is in a highly heated gaseous state, which the rain of atoms constantly falling on, or other cause of gravitation, must tend to drive in towards the sun's centre. This condensation of ponderable matter upon itself must increase the temperature still higher, producing or maintaining thereby that dissociation of the elementary atoms that manifests itself by their incandescent light, as well as by the dark Frauenhofer lines in the solar spectrum. The Ether finally receives back from the glowing sun upon its isotropic mass of temporarily arrested and comparatively quiescent atoms the surplus energy given off by the sun, in the form of the short and intensely rapid transverse vibrations of radiant light and heat that pass through infinite space in all directions, a few of which reach our earth with the speed of 186,000 miles a second, and bring to us Light, Heat and Life. Each far off star that we see at night, the nearest one 300,000 times more distant than our Sun, repeats this wonderful action under the like impulses of the Cosmic Ether, bringing without doubt to its planets —ever invisible to us—the like gifts of light and life.

An objection made to the Atomic theory of gravitation is that "if one body (the earth, for instance) shields another body (the moon, or a falling stone) from the impact of the atoms between them, resulting in the movement of both masses in the line of least resistance, this shielding of impacts would be in proportion to the half diameter of the respective bodies; which proportion is incorrect, as gravitation is as the mass, or weight, not as the area." The protection of one body by the other would not be as the area, but as the mass. It is true that the respective bodies would shield one another in proportion to their half diameters, but the effect thereof would be in proportion to their mass. The Ether penetrates the interstices of all bodies, however great, and must, therefore, *in part only*, pass through them, doubtlessly in some definite though unknown ratio. The Ethereal molecules would lose their motion in direct proportion to the number and nature of the *molecules in the mass* that absorbed their motion, being changed partly into molecular motion of the respective molecules, which are known to be in an actual state of vibratory motion, and partly are changed into the translatory motion of the mass of the planets; which motions, from being naturally tangents to their orbits, are forced at right angles thereto into the curves of their ellipses. The impulsive action of the ethereal atoms would therefore diminish in the ratio that the respective masses of ponderable molecules absorbed their motion —not be kept off as rain-drops would be by an umbrella.

The difficulty of accounting for the origin and maintenance of the inherent motion of the atoms of the Ether in their free path is as great as in accounting for the vibratory motion of the atoms of solid, liquid or gaseous matter, but not greater. It is the question concerning the First Cause! To this question human intelligence can give no definite answer. It should be remembered, though, that it is more philosophical to assume that the Ether which pervades the universe, extending far beyond those regions from which the light of the most distant star has been traveling to us for hundreds of years since it was emitted, should be the birthplace and dwelling-place of primordial motion, rather than that each star, nebula or mass of ponderable molecules should be the original source of an independent, inborn energy.

Whether the atoms of the Ether are or are not the cause of gravitation, we know that the ether is the conveyer to us of all other energy—that it alone is the occupant of infinite space—that it binds together in one connected whole the infinity of worlds, the universe of matter. It reveals to us also that what we call MATTER is something known to us only by the manifestations of forces, indestructible and eternal.

If the diffusion of heat, as stated by Lord Kelvin and others, is absolute, and the consequent dissipation of energy (Entropy) irreversible—which it would not necessarily be if the atomic theory of the Ether is the true one—the Ether must ultimately receive as heat vibrations the total amount of heat emitted by the suns (stars) that has not been converted into other forms of energy, or that, having been so converted, again on its expenditure appears as heat of low intensity. We have no positive evidence from the knowledge or the history of the past, in astronomical records or observed facts, that such dissipation and loss of solar energy has occurred. The rate of loss may be too low and historic time too short for the fact to be determined. In reference to this, J. Clerk Maxwell remarks: "The idea of dissipation of energy depends upon the extent of our knowledge. Available energy is energy which we can direct into any desired channel. Dissipated energy is energy which we cannot lay hold of and direct at pleasure, such as the energy of the confused agitation of molecules which we call heat (of low intensity). The notion of dissipated energy could not occur to a being who could not turn any of the energies of nature to account, or to one who could trace the motion of every molecule and seize it at the right moment. It is only to a being in the intermediate stage, who can lay hold of some forms of energy while others elude his grasp, that energy appears to be passing inevitably from the available to the dissipated state." * According to the one view here presented, the atomic motion of the Ether is the beginning of all—the birthplace of energy. According to the other view, that of a solid Ether, it is its end and graveyard: Entropy! Which is it?

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* J. Clerk Maxwell. Ency. Brit. 9th Edit. Vol. 7.

CHAPTER XVI

GEOGNOSY AND FORMATION OF THE EARTH'S CRUST—RESUMÉ OF THE PAST PAGES.

THE Science of Mineralogy teaches us to read in the minerals that the crust of the Earth exposes to us the records of past chemical actions that now rest quiet in their affinities; satisfied and permanent under the present conditions of temperature and atmospheric pressure. *How* many of these minerals were formed it is often impossible to conceive. In what way the Carbon of the Diamond, for instance, was enabled to crystallize into the relatively large masses in which it is found is a problem hard to solve. The crust of the earth, so far as accessible to us, is composed almost entirely of oxidized bodies; the compounds of Chlorine with the alkaline metals, with Calcium and Magnesium—more rarely native Copper and the Metallic Sulphides being nearly the only exceptions. The great density of the earth, as a *whole*, compared to that of the materials forming the *crust*—which alone is accessible to us, is as 5.5 is to 2.7, while water, which constitutes two-thirds of the surface has a density of only 1. ; proves that the inner mass of the earth beneath the crust is composed of much heavier substances than the crust itself. After making due allowance for all possible increase of density by compression from the superincumbent exterior, it necessitates the view that the interior is formed by the heavier metals, with possibly some of their sulphides. The fallen aerolites by their analysis support this view, since most of them consist of metallic iron united with small percentages of nickel, cobalt and other metals, showing the absence of oxygen in their former state. Native or metallic iron is never found on or in the earth, excepting very rarely in the form of small metallic grains in Basalt; the latter a product of ejections of lava, or fused volcanic matter, from fissures in the rocks of the earth's surface. This condition of the heavier metals of the earth's interior is what might be expected from the theory of the earth's evolution, the high temperature of the molten mass dissociating the elements, and, as the molecules cooled, permitting the denser and more condensible atoms to become the centre of the forming mass. After the earth became cool enough to allow the present conditions of chemical affinities to exist, the metals were excluded by their own mass from all but external surface contact with oxygen, as well in its union with hydrogen—water—which the hot metals might decompose, as with the uncombined oxygen of the air, diluted by the chemically indifferent Nitrogen, with which it is mechanically mixed but not chemically united.

Carbon, which in its first molecular condition was probably combined with Silicon, with Calcium or with the other metallic bases of the earth, as carbides, would next possibly unite with the oxygen or water, to form at first Acetylene, Methane, Ethane, or other carbo-hydrides, then later, with access of air, by combustion forming Carbon Dioxide, setting silica, or calcic hydrate, free; perhaps also permitting the formation of Petroleum, while free oxygen was yet excluded from the nascent carbo-hydrides. The carbon dioxide formed would escape into the atmosphere. The farther cooling of the earth would permit the luxuriant growth of vegetation that, absorbing the carbon dioxide into plant tissues have ultimately yielded us the coal measures—the geologic conditions permitting also the formation of the limestones of the same measures from the calcic and magnesian hydrates arising from the parent carbides: thus explaining in part the massive occurrences of calcic and magnesian carbonates in the Dolomites and other mountain ranges, whose immense deposits seem to require a geogenic theory for their primary occurrence, and are inadequately accounted for by the secondary metamorphoses of coraline, sea shell and infusorial growths.

The consideration of the anterior geognosy of the earth, as well as its later geological evolution and changes, to fit it for the progressive development of higher and higher forms of life, is a subject so vast in its scope and so infinite in its details as to lie beyond the limits of our purpose.

In concluding our view of *inorganic nature* a short resumé of what thus far has been said of the PATH OF EVOLUTION OF HUMAN KNOWLEDGE, may be of service. We have tried to show:

1st. That before and during the time of scholasticism the efforts and time of learned men were almost exclusively spent in arguing upon and endeavoring to reconcile the discordant views of the followers of Plato and Aristotle.

2d. The Church had adopted the Aristotelian Philosophy (which was a mixture of the Platonic and Aristotelian doctrines) practically as a matter of faith, and rejected as heretical all theories that were discordant with—or that even discussed—the truth thereof.

3d. As early as the Fifteenth Century, the theory that the Sun was the centre of the solar system was maintained by some Philosophers. In the Sixteenth

Century it was demonstrated mathematically to be a fact, and was so held by those best competent to know. The Church, whether Catholic or Protestant, refused acceptance to its demonstration; ignored it, or treated it as a heresy. In the Seventeenth Century Giordano Bruno was burned to death for maintaining the doctrine; and Galileo for the same cause was imprisoned and forced to recant.

4th. Until the time of Descartes, the minds of men, even without reference to the Church, were under the guidance of authority. What Aristotle taught was what others sought to know. Descartes threw away all old learning, and tried to think for himself. Better think wrongly than think only because others so thought.

5th. Science as yet was not. Chemistry was Alchemy, and Astronomy was Astrology. All reasoning was deductive only. Lord Bacon first taught that experiments and observations should be made, and their results would lead to the *axiom*, or absolute truth, sought for. He dignified the search into the phenomena of nature, which before him had been thought ignoble and debasing.

Sir Isaac Newton gave the first great demonstration of the value of this idea of science. His discoveries, not his theories, gave new light to light itself, and showed men the bonds that hold our world in its place and course.

6th. The existence of the ethereal medium was postulated by Newton as essential to the theory of light and to the existence of gravitation. The theory of an interplanetary Ether has been held since more than 500 years B. C. The doctrine then rested on a-priori reasoning only; since Newton's time the study of the conditions of light, heat and electricity has necessitated the assumption that such a medium fills interstellar space and the interstices of matter. From the very nature of its supposed properties it must be impossible to show its physical presence; but the coincidence between the observed phenomena in the transmission of the three forms of energy above named, and the properties that such a medium would necessarily possess, are so many and so varied that the non-existence of the Ether seems impossible.

The nature of the cause of gravitation, though most probably dependent also upon the Ether, or being one of its forms of motion, is still an undetermined problem. It is probable that the Ether possesses the characteristics of a gas, as known under the Kinetic theory, excepting that its atomic motion is inherent in itself, and that its vibratory molar or isotropic motion is the transference of heat, light and electricity. It is not ponderable matter.

7th. All substances are composed of atoms combined into molecular masses. These molecules are in constant motion, their condition varying from that of a solid, in which they have only vibratory motion, to that of a liquid, in which they have vibratory and also limited translatory motion, and to that of a gas in which they have vibratory motion as a consistent molar substance, or mass, and also unlimited molecular, translatory motion. These three conditions are dependent upon that state of inter-atomic motion called heat. It is supposed to be absent entirely from all matter at the temperature of the absolute zero (— 460 degrees F.). By which absence of heat all bodies previously gases or liquids would become solids, and all vibratory motion in matter, such as heat, would cease. With the increase of the atomic motion of heat, the several stages of fusion or liquidity, and of vaporization, or the gaseous state, appear. A definite amount of heat motion disappearing as heat in each change of state, being transformed into the increased molecular motion of the liquid or of the gas (with water 144 degrees F., in the melting of ice; 965 degrees F. in water when boiling). The molecules of a gas move constantly in right lines in all directions until they meet in collision one with another, or with the walls restraining their expansion.

8th. The discovery that the ultimate atoms of matter were of natures different one from another, having affinities for certain atoms in preference to others, and where combining with each other, doing so only in definite ratios peculiar to each elementary atom, established Chemistry upon a scientific basis. The *abstract nature* of chemical affinity, or that which causes the combination of atoms into molecules possessing other and new properties, is still unknown. We know that each element has definite and peculiar properties, but why they are different we know not.

9th. The atoms of matter are indestructible, nor can they be created. Energy is equally incapable of being created and of being destroyed. We can change the *combinations* of the atoms and the *manifestations* of energy. The latter is brought to us in the form of heat from the Sun, the centre of our Solar system, through the medium of the Ether. Apparently, energy is lost to the earth through the same medium, into which it passes as diffused heat. Whether this is really so, or whether it is merely an exchange of diffused solar heat for gravitation or other forms of energy exerted by the ether upon the sun and planets, is a problem that has been but little discussed and is as yet unsolved.

10th. We have learned thus far by the observation of nature's phenomena that a uniform system exists throughout—that no break occurs in the chain of causation. All the processes have an established order in which they move and have ever moved· What are called the "Laws of Nature" is simply the recognition of the fact that, so long as the conditions in which phenomena occur, remain the same, the phenomena will be the same. No change can or will occur without an adequate and sufficient cause, itself determined by existing relations that are established between elementary matter and all the forms of energy.

In the inorganic world the combinations formed and the phenomena shown by a group of molecules remain permanently unchanged so long as the surrounding conditions outside of the mass remain the same. Even the explosive combinations of Nitrogen with Chlorine, or with other elements, remain unaltered if not exposed to mechanical or vibratory motion. The constituents of a mineral when once united stay unchanged, unless new surfaces are presented to the air or water, or changes in temperature occur. Rocks and mountains rise or are washed away; but the earth's contraction, often producing volcanoes and earthquakes, causes the one, and the rain, heat or frost the other. The planets continue in their courses, but would move from it in a right line, a tangent to their orbits, under the impulse to preserve their velocity and direction, were they not deflected constantly from their direction by a force acting at right angles to their tangents, causing them to gravitate towards the sun. So it is with all around us. That which is, is. The cause that made it as it is now, continues. The fiery glow that once held this globe a molten mass, as our sister planet, Jupiter, is yet; died away millions of years ago; unless Solar changes come, the mineral world will remain essentially unaltered; until then Birth does not enter it, nor will Death affect it.

CHAPTER XVII

LIFE

LIFE COMES ONLY FROM LIFE—HAECKEL'S MONERA. BACTERIA—PHAGOCYTES, OR WHITE CORPUSCLES.

HERBERT SPENCER very truly says: "To those who accept the general doctrine of Evolution it needs scarcely to be pointed out that classifications are subjective conceptions which have no absolute demarcations in nature corresponding to them. They are appliances by which we limit and arrange the matters under investigation, and so facilitate our thinking."

This remark, prefacing his endeavor to define what Life is, and intended to lead up by successive steps to his definition ultimately given, though true in its general bearing, is certainly not applicable in our present state of knowledge to the classification which separates that which has life, from that which has it not.

Like almost every term of wide signification, it is difficult to define exactly what Life is. Herbert

Spencer, after carefully weighing each word and its meaning, gives this: "Life is the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external co-existences and sequences." John Fiske* remarks that metaphysicians object that this is a definition, not of Life, but of the circumstances in which Life is manifested," but adds that Mr. Lewes answers "that Life is a process. It is neither a substance nor a force," and approves of the definition as appropriate. In this instance, apparently, the metaphysicians are correct. Mr. Spencer's definition is not a definition of the process or processess that either constitute or manifest life; it is a statement of the conditions, without which life is excluded, rather than a description of what Life is. This is shown, not only in the sentence itself, but also in the chapters of Mr. Spencer's Biology, wherein he carefully adds to the partial definition as at first given, word after word, to distinguish it from the definitions of other and older writers, whose definitions embraced too wide fields, including therein crystallization, the action of galvanic batteries, the changes by decomposition in a dead body, etc. Since his definition was published, nearly forty-five years ago, the doctrine of the conversion and the conservation of Energy has become more firmly established. The physics of the Ether now place together, if not identify as one and the same, phenomena which were once considered to have nothing in common. Life is now thought to be directly and absolutely dependent upon the energy exerted by and through the Ether.

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* Cosmic Philosophy. Vol. 2d. P. 67.

The definition of Life here given expresses better what it is now thought to be than the one that was formulated by Herbert Spencer forty odd years ago.

Life is that form of Energy, which, through an existing organism, alters and assimilates similar and dissimilar molecules into combinations with the original structure, and which, though keeping or increasing its own organism and its functions, can separate a part of its substance to form a new body with properties and powers like its own.

In this statement recognition is given to the correlation of the energy that life manifests with other forms of energy. It is endeavored, later on, to show also that all the phenomena that Life offers, including sensation, consciousness and will, have therein their origin; the medium, the Plasmodium of plant or animal life, being the *mechanism* only through which this protean power finds expression. The mechanism may be, in the simpler forms of life, apparently without differentiation of parts, but becomes highly differentiated and complex in organization as the life of the class rises higher and higher in function and capacities. The mechanisms thus required are and can only be derived from an *organism already existing*. For it is proved as clearly as it is possible to prove a negative that *spontaneous generation does not exist.*

It is not probable, but it may be, that the future will reveal to us conditions that determine the formation of an organic living cell, or its plasmodium, from its inorganic constituents otherwise than from a pre-existing parent organism. As yet life has never been brought by man directly into being from the inorganic world, though every conceivable means has been tried. Many persons have thought that they had shown the formation of life in solutions protected from the introduction of existing life; but careful examination has always shown that in some way access to the outer world had been permitted, or the pre-existing life therein had not been destroyed. With greater care the maxim, "Omne vivum e vivo," has invariably proved to be true.

The phenomena that constitute Life, in its origin and relation to those of Inorganic nature, are best studied in its lowest and simplest forms, especially in those of Plant life. Haeckel and many other writers, in treating of the early forms of life, higher in type than the so-called Monera, have dwelt almost exclusively upon the developments of the details of *Animal* life, neglecting the simpler structures of Plant life. This procedure, though natural enough to the professed Biologist, is scarcely so well adapted to the needs of the general reader, who can seldom refer to the animal structure itself. The greater complexity of the animal organism, even though of a low type, compared to that of the plant, renders it far more difficult to follow the initial phenomena that life manifests, which, even in plants, lie almost beyond human understanding. For this reason attention has been drawn, with a few exceptions, to the study of plant life only. It alone can show the dividing line between the inorganic world and organic life—its origin and its reproduction. All who choose can readily watch and study it.

The simple cell of a protococcus, or the protean forms of an amœba—the one believed to belong to plant life, the other to animal life, and each so small as to be invisible to unaided vision—yet contain within themselves that mystery of existence: the potency of life. The doctrine of Evolution teaches us that from these beginnings may be evolved the highest types of life. The infinite varieties of cellular structure, the formation of tissue, the occurrence of chlorophyll in the delicate green leaf, whose wonder-working power maintains breath and food for all that breathe or live; the noblest forms of animal life, all may be traced back to the modifications of these or similar primordial structures. They are disseminated widely throughout all nature. It is difficult to exclude their presence when we wish to. They can be destroyed by heat or by boiling, but, like creatures of a higher order, though we destroy them, we cannot create them.

The chemical composition of these bodies, or of Protoplasm, is nearly identical, whether in plants or animals, all consisting of albumonoids—themselves composed of carbon, hydrogen, nitrogen, oxygen, with small quantities of sulphur and phosphorus. Water constitutes usually over eighty per cent. of their mass. It is very difficult with some of the lowest forms to decide whether they should be viewed as plants or animals. They move from place to place, but are without organs of any kind, many of them being formless, gelatinous masses, whose shape constantly changes by the protrusion of any one portion of their mass in one or another direction, for locomotion, or to absorb through any part of their substance such material as they feed upon. Haeckle places them in a specific class—" Monera "—as being neither animal nor plant. Of these the Amœba are placed by other writers in the animal line, principally on account of the nature of their food, but also from their general resemblance to the gelatinous bodies of the Foraminifera, or shell-forming Rhizopods. Other gelatinous, formless masses, the Myzomycetes, are considered to be Fungi, because their slimy substance passes into another life stage, becomes fixed, and produce sporophores, with cell formation. In the one stage they might be rightly called animals, and have often been so classed. In the second or germ-bearing stage they more resemble plants.

A widely spread family of the lowest forms of vegetable organism, or of Haeckle's Monera, visible only under the microscope, are those known as Bacteria, Bacilli, Microbes, etc. Their influence on the higher forms of life, both animal and vegetable, for good and for evil is becoming daily more manifest. To the presence of some of them are due the frightful pestilences that have scourged mankind. They are the cause of many of the specific contagious and epidemic sicknesses that afflict us; of Anthrax in flocks, cattle and man; of typhoid, of typhus, and of other fevers. It is more than probable that consumption, pneumonia in its typhoid form, in fact, most diseases not arising from organic lesions, non-assimilation, or functional defects, owe their origin and continued existence to these foreign growths in the animal economy, or to the morbific changes their presence induces. In surgery, the precautions taken to destroy their germs, if present, and to avoid their later introduction from without, have revolutionized the art. Operations are now undertaken with impunity and with the assurance of success that less than a generation ago would have been almost as necessarily fatal as decapitation itself. With proper care their exclusion and consequently, septicaemia; can almost always be avoided.

Instruments of evil, as Bacteria thus often are, many of them are yet of great utility. The Bacteria Termo is most frequently the organism by which the effete tissues of the dead animal or plant are decomposed, and their elements returned to the soil or atmosphere, again to enter into new living structures. If any forms of once living tissue, muscular fibre, meat broth, farinaceous food, vegetables or their infusions, are subjected to the temperature of boiling water, so as to destroy the Bacteria and germs that may be present, the said substances may be preserved indefinitely, even if the free access of air be permitted; provided that care be taken to filter out, or otherwise remove, all germs that may be present in the entering air. Without Bacteria, the Earth would be covered with the dead remains of past vitality, locking up in a useless form the molecules that have served their part in maintaining the life that is gone, but which the Bacteria set free to enter the storehouse of nature, again to be drawn upon to minister to new lives to come.

When we consign the body to the grave, "the dust to dust," it is not to be, as Job says, "that the worm shall feed sweetly upon him," for a host of creatures invisible to sight have taken possession long before, and have begun their work. The grave rather hinders than helps it; but it covers up and hides from our sight the changes that would offend our senses, until their work is done, and the elements —through the medium of plant-life—again may live.

Considered from the above standpoint, Kerner Von Marilaun (Das Pflanzenleben) justly says: "The horror of putridity is inborn with every man, and all that is associated with it, the whole brood of Bacteria, are looked upon with half averted eyes. It requires a sort of self-restraint to give to the processes thereof that consideration which they deserve. When we overcome our repugnance, and without prejudice observe, we are forced to conclude that to putrefaction properly belongs the continuance of vegetable and of animal life. Were the innumerable plants that die within a year not decomposed, but permitted to remain, a certain amount of Nitrogen and of Carbon would be withdrawn from the circle of life. If this were repeated from year to year, a time would come at last when all Nitrogen and

Carbon would be held within the bodies of the dead, and the earth would become a vast field of corpses."*

Some Bacteria are efficient in enabling the roots of certain plants and trees to obtain nitrogen from Ammonia Salts and from the air. It is now thought that they are more important factors in providing food to plants than was dreamt of heretofore.

The gases evolved from the decay of bodies, animal especially, contain ammoniacal sulphides, phosphides, butyrates, volatile fatty acids, and other evil-smelling compounds that serve to warn off and to keep away the living, to whom the bacteria and the immediate products of decomposition would be injurious. After their work is done the bacteria are carried off in the water, or when dried blown about and scattered again throughout the world. All that finally remain of the organism are some nitrates and some little earthy substances that the living body had gathered in. Dust and Ashes!

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* Anton Kerner von Marilaun was born at Mautern, Lower Austria, November 12, 1831; died at Vienna, June 20, 1898. He studied in Vienna, and practiced medicine there for two years; in 1855 he was appointed to a professorship, and in 1858 was made the Professor of Botany in the Technical High School of Ofen. From this time he devoted himself exclusively to the study of Botany. He held the Chair of Professor of Botany at the Polytechnical Schools of Buda; of Natural History at the University of Innsbruch, and of Botany at the University of Vienna, and was a member of the Academie des Sciences. In 1877 he was ennobled; created "Ritter von Marilaun," and made Director of the Museum and the Botanical Garden in Vienna. He gave much attention to the Alpine Flora, and instituted experimental gardens, at high elevations, in the Tyrol.

He published many works; among them the "Flora der Bauerngarten in Deutschland," "Die Niederöstreichischen Weiden," "Die Alpenwirtschaft in Tyrol," "Die Abhängigkeit der Pflanzengestalt vou Klima und Boden," Die Schutzmittel des Pollens gegen vorzeitiger Befruchtung," "Die Schutzmittel der Blüten gegen unberufene Gäste." His largest work is "Das Pflanzenleben." 1891. 2 vols. It is admirable for its profuse illustrations in the text and very many beautifully executed chromo-types, but most admirable for the clear, though elaborate, description, of every stage in the physiology of plant life and modes of reproduction. A second edition of the work appeared in 1898.

The Bacteria are the smallest of known organized beings: the largest of them are not over $\frac{1}{12500}$ of an inch in diameter, the smallest less than $\frac{1}{50000}$. They consist of protoplasm, and have the shape of spheroids, or of short cylinders, rods, and threads. Of these, some are straight, others bow-shaped, curved or spiral. The exterior, when moist, is gelatinous, but when dried becomes like a crust. They grow and multiply with astonishing rapidity in fluids suitable for their nourishment. The rod-like shapes extend in length, and then divide into two equal parts—each half again dividing, when a certain length is attained. Under favorable conditions, in most varieties, spores or germs are formed. These are spherical, with thick walls, and refract light strongly. It has been observed that a new formed bacterian cell within twenty minutes will so increase in length as to reach the limit of its normal growth; then it will divide in two; and so repeat indefinitely. It has been calculated that from a single cell within *eight hours* over sixteen million new cells are formed. Such growth can, of course, take place only at the expense of the nourishing fluid. The most favorable temperature for them is from 95 to 99 degrees F. When we consider that this is the normal temperature of the blood, and that it contains all the elements required for their development, it is easy to understand why they should so rapidly develop therein, and what serious interferences with the vital processes must necessarily follow. Their excessive minuteness gives them access to every part of the system, whither they are carried with the blood. It can thus be seen why the Comma Bacillus—the cause of Asiatic Cholera—should so rapidly cause death. The wonder is, why do not all die whom the disease attacks? The air we inhale and the water we drink usually contain hundreds and thousands of the spores of bacteria, or bacteria themselves, many of which are destructive to health or life. A single one of them is sufficient to produce thousands of their kind within a few hours. Life in the higher organisms would be scarcely possible were it not that a constant battle is waged against them in the blood itself.

Besides the red globules that are the main active constituents of the blood, and upon whose living powers life depends, there are present in much smaller numbers the white corpuscles. There is in health only about one of them to over three hundred and fifty of the red, but their aggregate number exceeds one thousand million in the blood of an average man. When viewed ordinarily under the microscope, they are seen to be colorless globules of protoplasm, a little larger than the red corpuscles. If the drop of blood containing them is warmed up again to the normal blood temperature, they are then seen to be full of life, and are, or at least closely resemble, Amœba. They throw out their substance into constantly changing forms (Pseudopodia) or limb-like extensions. They move independently from place to place, and seize upon particles in the fluid which they absorb into their substance. They pass into all the vessels of the body by means of their contractile power of changing shape—through apertures far smaller than their original form. (Dr. Johannes Ranke, "Der Mensch," Leipsig, 1887. B.1. S. 225).

Legrand and Leville* describe experiments made with the white corpuscles (Leucocytes) and the Bacillus Subtillus, in which they have seen the Leucocytes seize and absorb the bacilla. Other Leucocytes then join the first, and attack and absorb as many bacilla as they can. Those thus absorbed would completely disappear. After having thus destroyed five or six microbes they would cease, but after a short time recommence again.

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* Larousse. Art. Phagocytes, 1889.

The observations of Metchnikoff made in Pasteur's laboratory show that the avidity with which the several forms of pathogenic bacteria are attacked by the leucocytes varies with the immunity of the animal. Thus the bacilla of Anthrax, that are rapidly fatal to sheep, cattle, rabbits, etc., are seldom found in the white globules after their hypodermic injection into these animals, not appearing to have been devoured by the leucocytes; while under the same conditions they abound in the leucocytes of the dog, and other animals who have greater resistance power to the disease. Metchnikoff gives as an axiom the statement that "the more refractory an animal is to a given disease, so in proportion are its phagocytes capable of absorbing and destroying the microbes that cause the said disease." Why is it, he asks, that the afflux of the white corpuscles to the point attacked by the microbes varies in the same animal with the specific microbes present? This, he answers, is due to the curious property that certain substances, when present, cause an attraction and others a repulsion of the Leucocytes; for instance, most chemical substances, albuminoids, acids and alkalies, etc. He claims for the leucocytes an obscure consciousness, at least, as great as that possessed by the bacteria, enabling them (the former) to move to the point that is attacked. This faculty, designated by the name of Chemitaxia (chimiotaxie), is positive or negative, attractive or repulsive, as the substance varies.

According to the view of other observers, the leucocytes are only the scavengers who remove the dead substances in the blood. The death of the pathogenic microbes is due to the various humors of the body, especially the serum of the blood, which contains a toxine substance that is fatal to their life and that acts thus as an antiseptic. Metchnikoff himself admits that it is probable the phagocytes are not the only means of defense at the disposition of the organism, and that several factors may jointly tend to the same end. (Revue Encycl$^{\underline{\text{pd}}}$, 1891–1894.)

The white corpuscles occur in great number in the spleen, amounting normally to over one to twenty of the red corpuscles. In this organ—whose especial function is yet unknown, and which permits life to be sustained even after its removal—the white corpuscles in disease, especially in some forms of anæmia, amount to more than one to three of the red. The spleen is the site of the ultimate removal of most of the invading bacteria. Whether it is also the scene of the formation of the white and red corpuscles, or that of their ultimate destruction, are questions still unsolved.

As already mentioned, Haeckle placed these low organisms, especially the amœbic forms, in the order "Monera," being neither plant nor animal. He considered them to be transition steps between the inorganic and the organic world and as having their origin in *spontaneous generation.* This doctrine, which in earlier times was generally held, was strongly advocated by him in his "Morphologie der Organismen," published in 1866, and in his later writings. The lapse of over thirty years since then, and the indefatigable investigations of hundreds of learned and skillful men, have failed in ever developing life where life did not previously exist. That in past geologic ages conditions permitting it may have existed which do not now exist, is possible; but it is opposed to all methods of true science to postulate as a necessary *truth* that of which observation and experiment has failed to *demonstrate the possibility!*

CHAPTER XVIII

THE FUNGI CAN LIVE ON ORGANIZED FOOD ONLY —THE CAUSE OF FERMENTATION—MUSHROOMS, LICHENS — THEIR IMPORTANT FUNCTIONS — CURIOUS ANOMALY IN THEIR STRUCTURES.

BACTERIA are now recognized as belonging to that form of vegetable life known as the Fungi. Their essential characteristic is, that even in their highly developed forms they are devoid of "Chlorophyll," that curious combination of protoplasm that, in the form of green globules in the leaf, appear to take the place of the red globules of the blood in the vertebrata, and like the red globules nourish and support their respective tissue formations. Since the presence of Chlorophyll is essential to the plant to enable it to assimilate for its nourishment, carbon, nitrogen and earthy salts from the carbon dioxide and nitrogen of the atmosphere and from the minerals of the earth, it follows that the fungi and all the plants without chlorophyll must be either parasites, existing upon the living juices of another existing life, or Saprophytes, organisms living on decaying matter. Among the microscopic forms of this order are the Saccharomyces (Torula cerevisia); the well-known yeast plant, the cause of alcoholic fermentation; the Lactic acid ferment, whose germs are not destroyed by ebullition at 212° F., that causes the souring of milk; and the various varieties of mucor or mould plants. These germs are met with everywhere, and seize greedily upon dead organic matter for their food and development. The yeast plant germs are present upon grapes and other fruit, so that when they are crushed the juice enters rapidly into fermentation. The growing plant takes from the molecules of grape sugar in solution such atoms thereof as it needs for its own nourishment. The atoms remaining divide themselves into nearly equal proportions by weight of alcohol and of carbon dioxide, the latter escaping in the gaseous form in effervescence. Small quantities of succinic acid and of glycerine are at the same time formed. The yeast plant multiplies or grows both by gemmation or throwing out buds, as well as by the formation of spores. The former is essentially the same as the process of division among the bacteria, but the new cellules usually remain connected with their parent cell, though the slightest pressure suffices to part them. At a temperature below 43° F. the growth is almost exclusively by gemmation; the process is slow and the evolution of carbon dioxide gradual, so that the yeast is not buoyed up by it to the surface, but remains mostly at the bottom of the vat. This constitutes the lower yeast (Unter Hefe) of the lager beer breweries. It is anaerobic; that is, its life and growth is independent of the presence of Oxygen. The fermentation thus produced is less liable to be contaminated with the growth of other mycodermic growths that might cause acidity or viscidity, and is best adapted to the fermentation of weak worts that, under more rapid action, would pass beyond control. At a higher temperature, say about 70° F., the upper yeast (Ober Hefe) is formed. The growth is much more rapid and the evolution of Carbon Dioxide more violent. Towards the latter part of the process a large portion of the cellules contain spores, which serve as new centres of growth, and which are carried off by the escaping gas and disseminated in the atmosphere. The fermentation of wine or other fruit juices is of a similar nature, though it is not necessary to add the yeast from previous operation as required in beer brewing, the grape juice obtaining from contact with the outer skin of the fruit when crushed the germ of the yeast plant, whose growth starts the fermentation.

Other widespread members of the family are the Mucor, or Mould plants, that attack most organic substances when exposed in a warm, damp place; the Penicilium Glaucum that forms the blue mould on bread, cheese, etc., is ubiquitous; its presence and that of allied forms among yeast plants often cause serious loss in the wine and brewing industries by promoting their own growth and thereby inducing other fermentations to the detriment of the formation of Alcohol.

The true vegetative portion of the fungi is the "Mycelium," which in the microscopic forms thus far noticed constitutes the only apparent organism; the spores, if seen at all, being excessively minute. Among the larger fungi the mycelium consists of a congeries of Hyphæ, the latter being the individual threads or stems that in the yeast plant or similar growths form the plant itself as visible to us. They are formed of cells of dense protoplasm placed end to end, containing protoplasm not distinguishable from other forms thereof. In many instances the hyphæ form closely interwoven or adhering masses of threads, which spread in all directions; they penetrate the substance of the organism upon which they are parasitic and which they cause to decay. In the larger fungi, known as Mushrooms, Toadstools, etc., the mycelium exists only beneath the surface of the ground, where it may persist for years unknown. It is vulgarly called the Spawn of the Mushroom. The

Thallus that appears on the surface is the reproductive portion, corresponding to the inflorescence of flowering plants, though as far as known it is asexual. When grown it consists of a fleshy, cup-shaped body, like an opened umbrella. The under side thereof is divided into numerous thin, knife-like plates on which are the hymenium and gills, on the surface of which are the spores. These are excessively small, about $\frac{1}{20,000}$ of an inch in size; they develop into hyphæ when they meet with a suitable soil. For cultivation, the already developed masses thereof, the mycelium, is employed, since development from the spores is a slow and uncertain procedure. These fungi, like all of the genus, contain much Nitrogen in their composition. Many varieties are edible; upwards of three hundred kinds are known to be wholesome and nutritious. A smaller number of the family are acrid and a few are highly poisonous, especially the Amenita, which, as they roughly resemble the common mushroom (Agaricus Campestris), have not unfrequently caused death by being mistakenly eaten for the latter. They, as well as all the others, obtain their nourishment from already existing organic matter. They are incapable of assimilating the mineral or ærial elements from the earth or air.

LICHENS.—When, in any part of the world, a rock surface is exposed to the weather for the first time, there will soon be found on it a vegetable growth that often resembles the dried bark of a tree, clinging closely to the stone, and partaking of, or rather giving to the stone its dominant color. In dry weather it is usually hard and somewhat friable, appearing indeed as if it were the dead residue from a former vegetation, rather than a still living plant. In damp weather the tissues absorb moisture rapidly, swell up and become partly or entirely green, or partly yellow, red and grey, mixed with green.

These plants, some of them so small even when grouped together as to seem rather a stain upon the face of the rock than a living structure, are Lichens, the most widely diffused of all forms of vegetation, extending from the sea-coast in the tropics to the highest summits of the arctic mountains. They are the *pioneers of the organic world;* they seize upon the naked rock for their domicile, and thrive and multiply where nothing else can find a foothold. Nor is their life ephemeral: they retain their position through the greatest drought, the highest heat of the tropics, and the intense cold of the highest arctic mountain summits. Though their constituent tissues die, they are soon replaced in detail by new growths, so that they appear immortal. The same patch of lichens has remained apparently unchanged upon stones in buildings for hundreds of years. Probably the life of many groups of them has far surpassed that of the longest lived tree known to history. Their debris, when washed down by rain from the rock above, has formed a soil retentive of the germs of mosses and other cryptogamia, they in their turn when dead decaying. When the successive increments have thus formed enough humus, mixed with the rootlets (hyphen) of the lichens and minute fragments of rock, disintegrated by the weather, they are able to give shelter and nourishment to the seeds of the higher plants. Grasses, weeds, bushes, and at last trees spring up, and a forest comes into being. Such has been the *path of evolution of vegetable life* in all parts of the globe. It begins with the simplest life, that of an organism without differentiation of parts other than a simple cellule; it gradually gives place to organisms of more complex structure as the formation of soil progresses and permits the acquisition of a higher life.

The family of Lichens owe their preservation, if not their existence, to an anomaly of structure peculiar to them. It has been stated that all of the fungi are devoid of chlorophyll, that constituent of plant life that alone is capable of decomposing carbon dioxide, appropriating its carbon to form starch, cellulose or sugar, and rejecting or exhaling again the oxygen into the atmosphere. Plants without chlorophyll therefore can live only on organic matter ready prepared, and are either sacrophytes—consumers of dead organisms—or parasites, living upon the tissues or juices of living creatures, from which they derive the juices for their own support. In almost every instance this parasitic life is injurious to its host. The latter suffers by the appropriation by another of that which had been prepared for itself, and its death often inevitably follows. The term parasite has now the meaning of non-reciprocity, the advantages being one-sided only, the one giving all and receiving nothing. The Lichen presents, however, a curious condition different therefrom, to which the term Symbiosis is applied, in which two separate and distinct organisms inseparably live together to their mutual advantage. Either, without the other would soon perish. Every Lichen is now known to be the combination of a Fungus and of an Alga, living individual lives, but permanently associated. The fungoid portion of the lichen seems to be the original plant that seized upon the alga in accordance with the parasitic nature of the fungoid family. The association thus formed, proving mutually advantageous, has been perpetuated, and has become universal throughout the numerous and various families of lichens. The fungus is found in several varieties, each of which is peculiar to the lichens, and is only found in connection with the algæ as a lichen. A few of the same algæ are known to exist with *independent life* as *Algœ.* Their union with the fungi gives rise to numerous species of lichens. The Gonidia, or cellules, containing the globules of chlorophyll, are almost identical with those of the Algæ. Thus those of Physica are like those of Protococcus; those of Collema like those of Nostoc; those of Omphalaria like those of Chroococcus, etc., etc.

The experiment has been made of mechanically separating the structures of the plants and cultivating them apart. The alga, a Protococcus Viridis, grew and multiplied readily. The fungus part lived for a time, did not increase, and soon died. The synthesis of a Lichen has been made by Gaston Bonnier (Revue Ency., 1893). He caught the spores of the fungus on a microscopic slide, and, after the necessary precautions to avoid the entrance of foreign germs, introduced a portion of the above-named algæ. The process, with the admission of pure air, was watched under the microscope, and showed the development in all its stages of a perfect and normal Lichen. In this union of two lives the fungus furnishes the hyphae that attach the plant to the rock; it also furnishes a shelter and support to the alga and its spores through the extremes of heat and cold, of drought and of excessive moisture; its own composition, rich in nitrogen, furnishes by endosmose that element essential to plasmodic structure; whilst it in return receives from the chlorophyll cellules of the algæ the carbo-hydrides that they have formed from the atmosphere, and by which the tissues and the starch-like or gelatinoid elements of the lichen can alone come into being.

Lichens, beside the important part they play in the general economy of nature in promoting, as already described, the formation of soil for the growth of the higher order of plants, contain many valuable plants. Cetraria, or Iceland Moss, furnishes a valuable food in regions where other food is scarce. The Reindeer depend for their existence on another variety, and many valuable dye-stuffs are prepared from other species.

CHAPTER XIX

ALGÆ, SEAWEED, CHLOROPHYLL CELLS, THEIR ORIGIN AND USE—EFFECT ON RAYS OF LIGHT—THE PROVIDERS OF OXYGEN—ALL LIFE IMPOSSIBLE WITHOUT CHLOROPHYLL—LIGHT AND HEAT ESSENTIAL TO ITS ACTION.

The Algæ, when existing alone, constitute the lowest and simplest forms of green or chlorophyll-bearing plants. Algæ are mostly aquatic, and live either entirely in the water or require wet or constantly damp positions, in which only they thrive. Their spores, or certain cells that split off from the others, can resist the absence of moisture, and serve to perpetuate their growth when favorable conditions again return. Many of them are very minute. Desmidiaceæ and Diatomaceæ in their thousand varieties being microscopic only, whilst some of the Fucacea are among the largest of all the vegetative world. Macrocystis Pyrifera, off the S. and S. W. coast of South America, sometimes exceeding a thousand feet in length. The floating masses of Sargassum in the sea beyond the Azores frightened Columbus. From their comparatively simple construction, though belonging to the Chlorophyllian plants, the processes of protoplasmic movement and structure can be studied in the algæ most advantageously.

The popular, though erroneous, conception that animal life is essentially distinguished from vegetable life by the former only having the power of voluntary motion is absolutely disproved when the growth of an alga is observed. "The resemblance that the earlier microscopists saw in the inner structure of the plant tissues to the waxen cells of a honeycomb gave birth to the terms 'cell' and 'cellular tissue,' and to the idea long prevalent that this cell formation was itself the creative, formative and self-productive tissue that constituted life. It is now known that it is not the body of the cell, but its slimy, colorless contents, the protoplasm, which is active in its self-created cell, and must be looked upon as the carrier of life, as the *living part itself.*" The term cell has become so imbedded in our language that we now speak of a naked cell, meaning thereby the protoplasm when it is not a cell—when it is devoid of an envelope, and is simply a drop or minute portion of shapeless, jelly-like matter, but which moves and is alive. It may form a portion of its substance into a denser exterior, giving rise thus to an envelope. It is only when a congeries of these particles are grouped close together that the appearance of a cellular structure arises. The most striking characteristic of living protoplasm is its temporary change of place, by a movement of the mass as a whole, as well as the displacement, and often the self-development, of its constituent parts. The envelopes formed by the protoplasm from its own substance take usually the form of tubular or elongated cells, in which the slimy mass of protoplasm is retained. This becomes filled with minute granules or corpuscles that are in constant motion, principally close to the sides of the cellules, leaving the middle of the protoplasmic mass comparatively free. In this latter there appear large vacant spaces or cavities, the "vacuoles," in which a watery fluid, the "sap juice," collects. The exterior of the vacuoles becomes denser by the thickening of the protoplasm, and which gradually form cross or diagonal bands in the interior. Among these partitions the current of protoplasm flows, carrying the corpuscles before described, mostly in contact with the cellules sides. The motion of the corpuscles and protoplasma is of a twisting, boring character. They move along the sides of the bands or cells continually—down one side, around and up the other. The particles move more rapidly the smaller they are, the larger ones at times coming to rest. This motion originates in the protoplasm itself—in the gelatinous, colorless and transparent lining or contiguous substance next to the denser and inactive cell envelope, between whose own substance and it no sharp dividing line exists, and which carries on in its flow the corpuscles as a running stream does the small pebbles and floating matter in its course.

Among these bodies the comparatively large *chlorophyll corpuscles* are seen. In view of the important functions they fulfil, their structure is surprisingly simple. So far as we can perceive, they differ but slightly from the mass of the protoplasm that surrounds them. Consisting externally of the usual dense plasmodium, their interior is formed of a porous network of interlaced tissues, somewhat resembling those of a sponge. The cavities of this colorless, spongy texture contain a green coloring matter dissolved in an oily medium that lines the wall coverings of the almost infinitely small spaces. The green coloring matter is readily soluble in alcohol, ether, and in chloroform, but is precipitated from the alcoholic solution in brown flocculi by the addition of water. When in solution, it is bright green by transmitted light, but appears blood-red by reflected light, and shows strong fluorescence. If a fatty oil is agitated with the alcoholic solution, the green color is taken up entirely by the oil, the alcohol retaining a yellow substance—Xanthophyll—dissolved. This is thought, however, by some to be a product of decomposition of the chlorophyll. It is the cause of the yellow coloring of the foliage in the autumn. The green substance contains, in combination, beside the hydrocarbons, about two per cent. of earthy and alkaline salts.* Iron is also essential. If it is absent in the nourishing fluids, the leaves are colorless, becoming green only when it is supplied. (Pierer's K. L., 1889.) The green substance constitutes only a small portion in weight of the corpuscles. After extraction by alcohol the corpuscle is colorless, but not appreciably diminished in size.

The presence of warmth, and especially of sunlight, is requisite for the production and the functional life of the Chloropyhll bodies. They first appear as colorless or yellowish granules in the young newly-formed cells embodied in the plasmodium, becoming rapidly green in the light of day. A temperature of at least 40 degrees F. is requisite for their development. Their functional activity increases with heat, though the too intense action of the solar rays is destructive. The green corpuscles are *alive*, surrounded with the protoplasm in which they group themselves towards the exterior surface of the stem or leaf. In many plants they appear like disks, presenting in moderate light their flat or broad sides to it; but when the heat or light of the rays become excessive they turn to it their narrow edges only. The number of the chlorophyll corpuscles varies in the plasma of the cells from two or three to upwards of many hundreds. In some of the Algæ they line the tubular cells so closely as to appear like a continuous, unbroken coating. In other varieties they form spiral bands; in others stellate, discontinuous, or overlapping bodies. In the leaves of the higher order of plants the upper layer of the leaf, the so-called Pallisades, contain five or six times the number of the green corpuscles that the lower layer, the spongy Parenchyma, do. In the former they lie so closely together that they appear to constitute the entire substance of the cell, but close examination, shows that they are only in the lining substance of the cells, their interior not containing even a single one, the plasmic cell sap, or sap juice, alone filling the interior.

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* Kerner Von Marilaun. Pflanzenleben. B. 1. S. 345.

In reference to the modus operandi of the Chlorophyll corpuscles by which their wonderful work is accomplished, Kerner Von Marilaun remarks: "If, after describing the form, arrangement and number of these bodies we should ask by what means do they accomplish the formation of organic matter in the chambers of their cells? we would find ourselves in the position of a seeker after knowledge who enters without an instructed guide the Laboratory of a Chemist who is working upon the higher synthesis.

He sees the apparatus arranged, a heap of materials provided, and also finds the finished educt prepared. He can notice whether heat or cold is applied, whether an increased or diminished pressure is made use of, and if he is practiced in such manipulations, can form a shrewd conjecture as to the connection between the operations; but in the individual details much will remain incomprehensible and much remain unknown. Especially will his knowledge be defective in respect to the nature of the materials used and of the acting forces. Thus it is when we watch the proceedings in the cell chambers wherein the chlorophyll corpuscles manifest their activity. We see the machinery for action, we know the salts and the gases brought together for working, we know that the sunbeams will be the impulsive force, and we know what will be the finished products that the chlorophyll corpuscles will put into their cells; but *how* the active forces work, *how* it is that the sunbeam is able to force the ultimate atoms to give up their combinations—to transport themselves apart and away, and then soon after to appear in quiet and permanent union in a totally different order, are questions that cannot be solved." *

It is comparatively easy to trace the several steps of an *analysis*, or process of decomposition—to follow the original atoms in their entrance into new combinations that they may form; but the work effected by the chlorophyll cells is far more difficult to understand. It is *synthetical*—the formation of new *organic* combinations and structures differentiated one from another, out of the salts and gases from the *inorganic* world, through the influence of the *solar rays*. The theory of their action upon chlorophyll is thus given: "These rays, when separated by a prism from each other, are found to differ in their action. The most effective in their deoxidizing work are those towards the red end of the spectrum—the *red*, *orange* and *yellow*, that are the least refrangible and have the *longest* and *slowest* wave length. These are the rays that produce the deoxidizing action of the chlorophyll upon carbon dioxide, whilst the blue, violet and ultra violet rays, the rapid, short wave length rays, are those that are chemically active and are oxidizing. The rays of white light are decomposed by the green chlorophyll, which absorbs and changes into *heat* the *blue* and *violet rays*, permitting the *red* and *yellow* rays to reach the plasmodium. The property of fluorescence possessed by chlorophyll, which enables the rapid short waves of violet light to be changed into the longer, slower waves of red light, is effective to the same end. When the Algæ are growing in the deep water of the sea, so far from the sands and rocks of the coast that the sandy or earthy debris thereof no longer changes the pure blue tint of the deep into the greenish color of the shallows, the absorption of the red waves of light by the blue water is so great that the chlorophyll is no longer adequate for the work required. Not only are the red and orange rays nearly all absorbed by the water, and only the more refrangible rays, the blue and violet, transmitted, but all the light rays so far lose their power that at a depth of about 350 feet no light is transmitted, and at this depth no plants live. In less depths, but beyond the reach of the waste from the rocks and shore, grow the Florideæ, Algæ, in which the chlorophyll is masked or replaced in part by Erythrophyll, the red matter of the red-colored seaweed. This substance, both by its own color transmitting unchanged the light rays that reach the plant surface as well as by its strong fluorescent properties that change the rapidity and length of the waves of light, compensates to a large extent for the deficiency of the desired red rays, and facilitates the decomposition of carbon dioxide and formation of the plant tissues. On the other hand, an excess of light may be injurious. Those plants that grow on the shores and sandbanks are exposed to an intense glare of light, too destructive of chlorophyll to be borne by the plant with safety. In these plants the surface is either provided with a rough, woolly, hair-like covering, or is of a dull, scaly character that shields the green corpuscles from the superabundance of the solar energy.

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* Pflanzenleben. B. 1., S. 360.

Most plants also that grow in very strong light have their leaves vertically arranged, so that the beams fall in lines parallel to the surface, while those that thrive best in the shade expose their surface horizontally, the direct rays, or diffused light of the sky, reaching them in lines at right angles to the leaf, and therefore most effectively. Thus it is seen that the active energy influencing the functions of the chlorophyll corpuscles is the all-pervading Ether that transmits to the budding leaf the vibrations of light and heat from the far distant Sun. In the absence of light and heat, the plant would be but little better than dead tissues.

The first step in the life action of chlorophyll appears to be the decomposition of water and of carbon dioxide; the elimination of oxygen and the synthesis of carbo-hydrates in the shape of some form of dissolved sugar or one of its many nearly isomeric relatives. Next follows the decomposition of alkaline or earthy nitrates, and of ammonium salts, which, with soluble sulphates and phosphates, are supplied by the sap juice to the protoplasm in which the corpuscles are imbedded, of which protoplasm the cell exteriors are constituted, and with which they are filled. From these inorganic molecules are derived the Sulphur, Phosphorus and other elements that are built up by the protoplasm into the albumen of which it is itself composed, and which grows thus by its own accretions. The formation of the higher organized molecules, in their respective order, Dextrine, Starch and Cellulose, or woody tissues, then follow, to be arranged in common with innumerable other molecular groupings of the elementary atoms according to the plan of organization of each variety of plant.*

In all the above syntheses, or the formation of the higher complex combinations of molecules peculiar to the manifestation of life, from the simpler, inorganic molecules of the mineral or aerial world, devoid of life, the immediate presence of light and warmth, the educts of the Ether, are *absolutely essential.*

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* *Ibid., et seq.*

CHAPTER XX

THE TRANSFERENCE OF ENERGY FROM LOWER TO HIGHER ORGANIZATION—REPRODUCTION IN THE ALGÆ—AGAMIC AND SEXUAL.

Another series of the phenomena involving the growth and development of the plant, and above all its reproduction by flowers and fruit, wherein the light of day is *unnecessary* if not injurious, is now to be considered. In discussing the phenomena of combustion it was shown that when many substances, elementary or molecular, containing carbon or hydrogen, united with oxygen, a certain elevation of temperature or external heat was required to induce the oxygen of the air to unite with the substance in question, but that when the union of oxygen therewith, or *combustion*, had begun, the chemical energy evolved was not only sufficient to maintain the temperature necessary for combustion, but a vast amount of surplus energy was developed, and passed away into the air or ether as heat of high intensity. This energy could be applied to many purposes, or, by appropriate means, made to assume many forms, such as physical motion or the generation of electricity, etc.; but whatever form it might assume, its origin was the same. The carbon and hydrogen, dissociated from their earlier combinations by the solar energy transmitted through the Ether, had been stored up as cellulose in the living plant, and afterwards, when excluded from atmospheric oxygen, remained as woody tissue or was changed into mineral coal. Heat thus became the form of energy in which the dead tissues of the once living plant were now available. It was different when the plant was living. An example of its mode of action then, may be taken from a contrivance in mechanics.

It often happens that it is desirable to raise to the top of a hill a part of the water that in a brook runs to waste at the foot thereof. This is conveniently done by causing a portion of the water to flow in a large tube for some distance down the declivity of the brook, the water escaping through a valve at the end. Just above this valve is another valve opening into a closed air chamber, to which is attached a small tube leading to the top of the hill. In operation the water flows down through the large tube and valve until the friction caused by its rapid flow raises and suddenly closes the exit valve. The momentum of the column of water, being instantaneously checked, expends its force by driving a portion of the water through the other valve and small tube to the hill-top, until—the water ceasing to flow in the main tube —the large valve again falls open by gravity; the flow recommences through it, when its full velocity again closes the main valve and so "da capo." By this arrangement, which is known as the hydraulic ram, a small but nearly constant and adequate supply of water is carried up to a reservoir many feet above its source in the bed of the brook.

In the living plant and in animals a transfer of the surplus energy occurs in some respects analogous to the action of the flowing water in the apparatus described. In the plant life, as well as in that of animals, the energy that is not available immediately or required for its momentary functions is stored up in the vessels until wanted, often in the shape of starch or fat. Partly even in daylight, but especially at night, when the chlorophyll molecules are no longer acting, processes of tissue formation are at work. These processes are essentially oxidizing: a portion of the hydrocarbons formed during the day unite with oxygen, and form again carbon dioxide and water, thus reversing the prior action of the chlorophyll corpuscles. This degradation, or falling down from the higher levels of chemical or organic construction to the lower level of inorganic affinities, would, if the plant were dead, be only attended with the development of heat. In the living plant it takes another course. As in the example given of the Hydraulic Ram, the vis viva of the moving water falling to a lower level imparts its active energy to raising a smaller part to a higher level, so the energy liberated by the products of oxidation in the living plant or animal raises another, though smaller, portion of the plasmodium or its structural forms to the higher level of more complex organization—forms the new cells and tissues of the growing plant, evolves in the lower forms of plant life such as the agamic algæ their reproductive spores, and in the higher developed Phanerogama, the intricate and beautiful structures of the sexual modes of reproduction, their flowers, fruit and seeds.

This oxidizing and constructive process *only*, is that which constitutes the life of the Fungi and of all those plants that are either parasitic or that live upon dead matter. Being without chlorophyll, they can obtain their sustenance only from food prepared by other lives. They can live, as all animals do, only from already organized matter, and, like animals, their food, when assimilated, builds up new tissue and new organisms by aid of the surplus energy set free in the oxidation and degradation of the molecular combinations that are effete and dead.

With animals, however, this surplus energy manifests itself also in part as muscular force and action; another part in animal heat, which is always present even in cold-blooded animals, though in a lesser degree than in the warm-blooded. The total heat produced by the combustion of carbon, hydrogen, etc., in the act of respiration is *exactly the same* as if the said substances were burned in the air by ordinary combustion. The heat, being slowly evolved, is, of course, far lower in *intensity*, though the *quantity* is the same. In animals, as in plants, it must be borne in mind, the phenomena of life are the exponents of the energy conveyed by the Ether, primarily to the plant, and through it to the animal. In addition, animal life is directly dependent upon solar light, heat, and the many influences therewith combined, that affect health and the exercise of its faculties.

The flowering of plants is entirely an oxidizing process in which chlorophyll has little or no part or action. No true flower—that is to say, no portion thereof that involves the functions of reproduction—is ever colored green. The peculiar properties of chlorophyll are those directly opposed to the changes required in the plasmodium out of which the constituent parts of the flower, and later on those of the seed vessel and its seeds, are to arise.

The mode of reproduction of Bacteria by division of the cellules with or without the formation of nuclei or spores has already been described. Among the next higher order, the lower Algæ, reproduction is often, even in the same individual, both asexual and sexual. In the tube-shaped Vaucheria Clavata the non-sexual process, viewed under the microscope, is curious and interesting. The tube-like structure of the plant terminates with rounded ends; close thereto a cellule several times longer than its diameter is formed. The chlorophyll granules form in the plasmodium contents, and partly fill the cell. A few hours later the cell bursts through the end of the tube. It now forms an ovoid body, dark green at one end and nearly colorless at the other. It parts from the parent plant and swims away in the surrounding water, apparently seeking a suitable place for lodgment, avoiding floating matter or other obstacles in its path. It stops at times, apparently to rest; resumes its course soon again. Its motion forward is at the rate of about three-quarters of an inch in a minute, though seemingly rapid under a miscroscope, crossing the field of vision in less than a second; it revolves on its longer axis and progresses, therefore, with a spiral, screw-like motion. This is produced by the ciliated or eyelash-like extensions that issue from its gelatinous substance in all directions, and by their incessant, alternate bending and straightening propel the globule forward. This motion continues for about two hours, when the periods for resting become more frequent and longer. The cellule, finding a suitable place, now finally comes to rest, preferably on the shady side of some fixed or large floating body; the cilia disappear or are withdrawn. The globule, until now a mass of naked plasmodium, hardens or thickens exteriorly, so as to form an envelope—a firm, transparent, colorless skin—the globule becoming uniformly green. After twenty-six hours a number of short, branching tubes arise from the cell thus formed. These tubes increase in size and length as the parent cell did, until in fourteen days their ends burst, and give birth to new cellules, that run again the life course thus described.

Other Algæ, whether multiplying sexually or asexually, produce similar plasmodic globules, which, either before or after their separation from the parent, burst and set free a swarm of minute ciliated protoplasma that move their pear-shaped bodies by means of their thread or whip-like cilia, two or more in number, in the manner above described. These swim alone, at times avoiding one another, or, if they come in contact by their forward ends, remain an instant so, then back away from each other and continue on their course. Others seek each other, remain side by side, and their gelatinous bodies melt into each other—their increased size and duplication of the number of their tentacular cilia alone indicating their former separate existence. Those that avoid each other have escaped from the same enveloping cell. Those that seek each other and blend into each other are from the chamber cells of different individuals. This is the procedure with the Ulothrix ("Curly hair," a fresh water Alpine Alga), and is the simplest conceivable form of fertilization among plants. In other Algæ (the Spirogyra, for instance), when the cells of different filaments are nearly in contact, they protrude their respective walls towards each other. The latter, which in these organisms are always soft and plastic, dissolve when the protrusions meet. The plasmodium in the opposite cells—in each now gathered into globules—pass from one into the other, and, uniting, form a single globule. This now fills with granules, and when ripe escapes through the side of the cell. Ultimately this globule bursts, liberating its contents; each granule, after its migratory existence, as before described, starts a new life, and by subdivision of its cell walls grows and forms a new plant like its parent. No difference can be observed in the appearance of the plasmodic globules before their junction, though without doubt a difference in composition does exist corresponding to their sexual distinctions.

The mode of reproduction of the higher fungi has already been described. That of many Cryptogama, the mosses, ferns and others are both sexual, and asexual, and often show a curious condition of alternate generation. The female cells or oospores germinate, and produce an embryo plant, which in the Ferns is a simple mass of cellular tissue. Its cells divide, a root is formed that descends, and a stem that ascends and bears leaves. On the under side of these, spores are formed; when ripe they escape, and, taking root, a new plant grows. After a time the sexual generation occurs, consisting in the production on the under part of the leaf of spores that develop into the antheridia and others into the archegonia, corresponding to the male and female fertilizing organs of the anthers and pistils of the plant-bearing flowers, or the phanerogama. These give birth to the oospores before mentioned, and the cycle begins again.

CHAPTER XXI

PHANEROGAMA, OR FLOWERING PLANTS — CONSTRUCTION OF FERTILIZING ORGANS—SEEDS—GERMINATION—CUTTINGS.

The higher order of plants, the Phanerogama, include all the plants that bear flowers, and therefore include all grasses, herbs, shrubs, bushes and trees, and such water plants that, although living in the water, bear flowers that bloom only in the air. The plants, without exception, contain chlorophyll, though but a small and unimportant part of the flowers themselves contain it. The florescence of the plant consists in the growth and development of the organs that are essential to the formation of the fruit, or seeds, in which lie the potency of the continuance of a new plant life.

Although the variety is almost infinite in the appearance and detail of construction of the tens of thousands of different flowers that exist, yet they all contain the same essential features. All have the same functions to perform. We can readily recognize on examination the mechanism by which it is to be accomplished, however varied in form and color it may be made, or however obscured by apparently needless replication of some parts or obliteration of others.

It is not at first sight very obvious why, in the economy of nature, it should be necessary, or rather that it should be so very often the case, that two separate individual plant lives should take part in the production of the fruits or seeds from which spring the existence of a new plant of the higher orders. As we have seen, the lower plants, the bacteria, the lower fungi and algæ, are non-sexual; yet even among the higher order of the Cryptograma sexual reproduction becomes more general as their evolution advances In the Phanerogama it is universal. It is true that in many flowers both the Stamen (male) and the Pistil (female) are present, the flowers being hermaphrodite; but in almost every instance the pistil is so conditioned or placed that the pollen from the stamens of the same flower cannot reach it, and fertilization can only occur by the pollen coming from a distant flower. The reason probably is that the florescence of a plant is exhausting to its vitality, possibly from the excessive consumption of certain constituent molecules, sometimes in one direction, sometimes in another. The joint lives of two organ isms may better supply the elements or conditions needed for the fertilized ovule that otherwise might be deficient if one plant only furnished all. The varying conditions of soil and exposure to light and moisture must also cause variations in structure in each plant, and give rise to such slight differences in constitution as to be favorable to greater perfection in the pollen and induce such changes as to lead to the higher evolution of its structure and functions. Be the cause what it may, and the principles of evolution best account for it, the fact is certain that the most intricate devices exist in innumerable instances by which the pollen immediately adjacent is excluded, and fertilization made possible only by the pollen being brought from other flowers by the wind, or very frequently by insects or birds, who seek the flowers that are far apart for the honey or other food secreted respectively for their attraction.

All flowers consist essentially of three distinct parts, all of which arise from modifications of the ordinary leaf of the plant. They are, *first*, the outer protecting envelopes, consisting of the calyx or lower cup-like leaves or sepals (often greenish and adjoining the stem), and the corolla or petals. The latter are usually the most conspicuous part of the flower, being often brilliantly colored and their texture exquisitely soft and delicate. The sepals and petals are generally five in number, although often there are more, and sometimes fewer. Their office is to close around and protect from sun, rain or other injury the inner and essential organs within their enclosure until they are fully ripe, and by their color and odor attract birds and insects from afar, by whose assistance the work of fertilization can often only be accomplished. *Second.* Within, next to the petals, are the stamens, bearing on or near their summits the Anthers, or male pollen-producing organs. They vary in number from one to several hundreds. When by cultivation the petals are rendered double, it is by some of the stamens becoming degenerated into petals. The Anthers are formed of two small lobes, or pod-like vessels, that open, when ripe, and discharge the pollen, a fine, powder-like substance, though often rendered cohesive in certain plants by a sticky, viscid fluid, which prevents its dissipation by the wind. *Third.* Within the circle of stamens, and occupying the centre of the flower, are placed the Pistil or Pistils, part of the female or ovule-bearing organs of the flower, which, after the flowers fades, are changed or grow, forming the fruit or seeds. It or *they* consist of one or more tubular structures or Carpels that arise from the centre and the end of the flower-bearing stem. If multiple, they may unite at the base into one receptacle or ovary, or each may have its own, and remain distinct throughout. Between the ovary and the summit extends the Style, a tube connecting the ovary with the Stigma. These latter vary in form, dependent upon whether the pollen is to be brought by the wind as fine dust, or whether it is to be transported by insects, or some similar means, in the shape of sticky lumps of coherent granules—in the one case forming flat, button-formed nodules, in other cases it arises above the stamens and terminates in a rod-like extension, which may be straight, bent, or contorted, on the surface of which a moist area is exposed, upon which the pollen falls and adheres. Various and complex devices exist by which the stigma may remove from an insect or bird the pollen with which it may be loaded, and which it had gathered from the anthers when seeking honey or other food in the same or in a different flower. The stigma connects through the style with the Ovary, in which, attached to a prolongation of the style—the Placenta—the ovula are formed. The ovary is usually spherical, and if there is more than one carpel the grooves on the outside coincide with the junctions thereof. After the contact of the pollen with the stigma, the ovula grow larger and finally mature into seeds; the ovary discharges them when fully ripe by opening or bursting its enveloping coats.

The pollen or life-giving principle and its action are thus described: "The pollen cells are differentiated into an outer cuticular layer or Extine, and an inner layer or Intine. The former is a firm membrane, sometimes smooth, sometimes covered with minute hairs, points or projections. It is generally yellow, and often covered with an oily or viscid secretion. The intine is thin, transparent and possesses great power of extension. The pollen grains vary from $\frac{1}{900}$ to $\frac{1}{700}$ of an inch in diameter; they are usually ellipsoidal, but sometimes spherical, cylindrical and even triangular and polyhedral.

Within the pollen grains is a granular semifluid protoplasmic matter, the Fovilla, together with some oily particles, and at times starch. The Fovilla contains small spherical granules about $\frac{1}{30,000}$ of an inch in diameter, and a few larger, elongated corpuscles which exhibit molecular movements. Moisture has a marked effect, causing the pollen grains to swell up by endosmose. If long continued, the extine becomes so distended as to split, or open in places. The intine is more distensible and is often forced through the pores or the ruptures of the extine in sac-like protrusions. Ultimately the inner membrane gives way and the fovilla escapes, often in tube-like processes. To guard against injury from the premature admission of water to the pollen cells, the stamens are protected by the inner petals of the Corolla. In wet weather or at nightfall one or more of them close firmly around the stamens, if the anthers are nearly ripe. In the same manner they protect the stigma until ready for its functions. The bell-shaped flowers then bend down more deeply, so as to offer their narrow base to the storm, and thus shelter their contents from the rain. The pollen must finally be brought in juxtaposition with the stigma; when the moist surface thereof causes the rupture of the pollen cell; or the contents thereof, the fovilla, escape wrapped in the long, minute tubular protrusions of the intine, thus affecting the union of the two plasmodia, the fovilla being transmitted through the plasma of the style and by the enclosed Placenta to the ovula, which slowly grow and ripen." *

After fertilization the anthers and stigma wither and decay; the petals fall and the calyx, if remaining, changes its form; the fruit, as the entire maturing ovary is now called, varies much, as is well known, in its nature. In such fruits as the apple, gooseberry, etc., it consists of a development of the Calyx and Ovary only. In that of the Hazel and the Oak it consists of the ovary, calyx and the Bracts (or the leaves partly developed into the calyx, below the latter). The pulpy matter in apples, pears and similar

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* J. H. Balfour, Ency. Brit., 1877.

edible fruits is one modification of the *Pericarp*, and is formed usually from the placenta, and serves proximately for the dissemination of the seeds, being eaten by animals, through whose digestive organs the seeds pass unchanged. In other fruits the pericarp is hard, ligneous and not digestible, and serves only as an additional protection to the enclosed seed or seeds until the conditions are favorable for germination. Their dissemination is provided for in many ways with which we are all familiar. In all seeds the active, living germ constitutes but a very small portion thereof. The embryo, or germ, is only a nodule, at or near one end of the seed. It is protected by its tough outer covering from the wet, and is capable of withstanding with impunity an excessive degree of cold. If kept dry, seeds retain the potency of life for many years.

The principal part of the seed consists of an amylaceous mass of granules of starch, albumen and oily substances, which serve as *food to the young plant*, and are consumed by it when it germinates and begins to grow. The processes of floration and of fructification are very exhausting to the parent plant. The formation of a flower and the growth of the seed require a large expenditure of material and of vital energy that are furnished by the oxidation or degradation of the parent tissues and of the stored-up oil, starch and organic matter prepared during the daylight, but partly consumed then, as well as at night. It is well known, moreover, that all grasses lose most of their nutritive properties after the formation of seed is completed.

When the young plant begins its independent life, or germinates, it requires at first no extraneous food, nor does it require sunlight. It contains within itself all that is needed excepting the energy furnished by moderate warmth, and the addition of a little moisture. With these supplied the seed protrudes a portion of its substance through an opening, or openings, in the outer coat; this thread or stem-like growth divides, one part striving up to the light and air, the other seeking the ground, if below it.

If at this time, before more changes occur, the seed be chemically examined, it will be found that with the first appearance of a sprout the contents of the seed have swollen, the starch has become sweet, and in a little time will change entirely into sugar, which again will disappear as the sprout increases, until roots and the rudimentary form of leaves appear. If now, the whole plant be removed and weighed, it will be found that, notwithstanding its increased bulk by moisture absorbed, it will weigh less than it did before it began to grow, the growth being not by the absorption of matter from without, but by the change within the seed—the nutritive matter therein, the starch, oil, gluten, dextrine, etc., passing first by conversion partly into sugar, and then into the plasma and the succulent vessels of the new growth, furnish by their oxidation, or running down the scale of molecular combination, the needed energy. This now finds expression partly in heat, but mainly in forming the new plasmodium, building up new cells, new corpuscles, new tissues and new leaves, until the original nutriment within the seed shell is exhausted, and the infant life, now strong in its own radicles and leaves, can independently enter the field of the inorganic world, and, provided with chlorophyll, struggle for its own existence.

Many plants, after shedding their seeds, at once wither and die. The continuance of their species is provided for sufficiently by the future growth from the seeds, and depends absolutely upon the new life only that is to issue therefrom. But should the development of the flower or seed be prevented by transferring the plant from its native climate to one so much colder that the flower and seeds have not time to receive the needed heat to ripen, or if the flowers as they begin to form are nipped off; the plant does not die, but forms on or near the root bud-like swellings, which develop into scions or layers (often called suckers), which preserve the life, and in the next or recurring Spring burst into leaf. In this way many of the annuals have been transformed into perennials.

With the majority of plants that are not strictly annuals the propagation of the plant life is by means of the scions or layers above mentioned, or *cuttings*, as the gardener calls them. If a leaf-bearing twig is cut off and embedded in earth, or, still better, grafted upon a stem of an older but vigorous plant of the same species, so that obliquely cut surfaces are held firmly in contact, the life continues. If in the earth, the leaf buds are transformed into rootlets which absorb nutrition from the soil, other buds throw out stems that strive upwards and soon form leaves, and a perfect plant is born. The grafted stem undergoes less change; the cellules of the fresh cut surfaces being in contact, the plasmodium of the older plant cell is transferred to those of the younger cutting, and the sap juice circulates through its vessels; the leaves of the cutting, containing chlorophyll cells, secrete and form the same plasmodium that they did when on the parent stock; the cutting grows, and often not only forms ultimately the entire tree, but preserves the characteristics of its origin. Often these characteristics, though sought for by the gardener, are really monstrosities, so far as the physiology of the plant itself is concerned. The soft shell of the Almond, the tender, thin skin of the peach, or the double petals of the rose, though desirable for the tastes of mankind, are not those best fitted for the life or propagation of the tree or bush. When accident or cultivation has produced seedless grapes, or other such abortive fruits, it is self-evident that the extinction of their kind would inevitably follow in course of time. The gardener, for his own profit merely, seeks the culture of plants and fruits, so far as practicable, from cuttings only.

All plants that arise from seed growth, excepting annuals, show a strong tendency to *atavism*—that is, a reversion to the ancestral condition or that of the wild state. The seedlings that spring up under a cherry, peach or apple tree will develop into vigorous trees, but their fruit will nearly always prove to be worthless. The exclusive, artificial culture in certain directions of particular qualities is not for the good of the plant itself. Even an over development of those properties that are essential to the seed growth may be injurious. Thus abnormally sweet and highly flavored fruits, though useful in tempting cattle or wild animals to eat them, and so scatter their seed abroad, will also attract very many insects to live upon their juice, who will deposit their eggs in the fruit; their larva attacking later the leaves, tissues, or even the seed itself, thus destroying the balance between the protective and the destructive forces of nature. Atavism may be viewed as the *reversal* of the processes of evolution, often injurious in its action; yet it is the conservative power that in the plant world restrains the unlimited and often undesirable exercise of the power of variation that the changes of sexual conditions and climatic influences exert, and which would retard rather than ultimately advance the benefits of evolution.

CHAPTER XXII

SENSATION IN PLANTS—VITAL ENERGY IN THE ETHER—ANIMAL LIFE—INCUBATION OF THE EGG—PROGRESSIVE CHANGES THEREIN.

IN describing the simplest organisms that manifest life, it was pointed out that no sharp dividing line exists between animal and plant life, and that it is often difficult, if not impossible, to say whether certain forms should be classed in one or in the other categories. The vulgar conception that recognized an animal as the only being with an innate potency of translatory motion is known to be erroneous. Not only have the lower forms of plant life the power of motion from place to place, but inversely many animals among the much higher orders are immutably fixed, often with less power of moving even any portion of their body than a flower possesses in the act of opening or closing its petals. Nor may the mental attributes of animals be totally denied to plants. They seem to possess in the lower, as well as in the higher orders, a certain *consciousness*, a selfdetermination of *purpose*, in seeking or avoiding light, in directing their rootlets towards water, in the movements of the stamens and pistils, and other phenomena of vegetative life, that are as curious to observe as they are difficult to explain.

In the absence of any tissues or fibres corresponding to the nervous systems of animals, one fails to find an explanation of the movements of the sensitive plant on being touched, or of the closing of the glandular hairs of the Sun-dew (Drosera) upon an insect that lights on the flower, to be quickly digested by the acid pepsin that the plant secretes. The leaves of the Venus Flytrap (Dionœa Muscipula) are furnished at their ends with two semi-circular lobes, provided inside with short, sharp bristles or thorns; the lobes have teeth-like projections on their margins, and they close together like the covers of a book. A viscid secretion on the inner surface attracts insects; on alighting thereon, the lobes close suddenly, imprisoning the insect, which dies and is digested. If small pieces of meat or other nitrogenous food are thrown on the open lobes, the same action results; but if sand, fragments of wood, or even amylaceous substances are scattered thereon, they produce no effect, and remain on the open lobes until washed off or blown away. Agitation of the plant, or mechanically touching any part, is at all times without effect.

In these and in many other plants provided with similar sensitive contrivances the plasmodium may be seen in motion in the vessels that appertain to the specialized organs. It appears to fulfill the functions that the nerves do in animals when they carry to and from the *brain* the impressions produced by the senses, and subsequently transfer therefrom the *will power* that controls muscular contraction. The mechanism, however, that would seem to be required for such substitution has never been observed, though it is said that electric currents have been noted, which might have some analogy with the electric-motor character of the nerves and muscles.

No structures or organs are known in plants that correspond to the cerebro-spinal nervous centres in animals. The conversion of the purely chemical and physical metamorphoses in the higher plants as well as in the lower orders, into the inexplicable phenomena of sensation, and voluntary motion, seems not to be relegated to a special division of the plasmodium, differentiated for that function, but to be the general attribute of the whole plasma. It shows itself as active not only in the specially sensitive plants above-named, but also in the petals of flowers, in the movement of leaves, and in the translatory motion of the young algæ cells and of their reproductive spores. It must be looked upon as a manifestation of that energy which, conveyed by or through the Ether, finds expression in other instances in animals through an intricate plexus of nerves and blood vessels, but which can also be manifested, when needed in a simpler form, by less complicated mechanism. Since the power or energy that acts is not inherent in the *plant*, but in the *Ether*, *air* and *light* that surrounds it, this power can find in the simple, shapeless, naked amœba, that looks like a drop of liquid gelatine, the capacities adequate for the conservation of life, the power of motion, sensation, volition, and ultimately evolution into a higher form of life, perhaps even into the very highest! An organism which has sprung from the very dust of the earth is animated by the same power that moves the life blood of men, and that may have in part come hither not only from the Sun, but also from other far off and unknown stars and worlds!

The distinctive line of demarcation separating plant from animal life, as already stated, is not the power of motion possessed by the latter, but the fact that all animal life depends alone upon the absorption of Oxygen in respiration and the consequent oxidation or combustion of the body and its tissues, thus liberating in various forms, the energy that had been stored up by the Ether in the living plants that the animal had consumed. To us, who move about on the floor of an aerial ocean, drawing therefrom the breath of life, but which our immersion in the water near us would quickly end, it seems at first thought strange that the respiration, on which all animal life depends, should be identically the same to the inhabitants of the water as to those of the land, the former breathing through the gills the oxygen dissolved in the water, the latter, through the lungs, that in the air. The water contains only four per cent. of its volume of free oxygen and the air twenty per cent.; yet as the contact of the fluid with the blood, through the gills, is more intimate than that of the air, with the blood in the lungs, it is even more effectual in its action. In all probability life was first manifested in the water. Many of its simpler forms are yet found there only. The order of their evolution seems to have been from fish to marine reptiles, then to land and flying reptiles; next, birds; and, lastly, the mammalia.

The phenomena of motion, sensation and consciousness, faintly and exceptionally existing in plant life, find their full demonstration in the life of animals. The debatable ground occupied by the lower forms—the "Monera" of Haeckle—has been mentioned, and they have been sufficiently discussed. Even to attempt the slightest sketch of the progressive complexity of structure that attends each upward step in the order of Animal Life would require this article to be a treatise on comparative physiology and zoology. To examine the dividing line between that which has *not* life and that which *has*, to note the first occurrence of organization, and to observe the way and the only way in which life is formed—a resultant from a preexisting life of a parent—has been our purpose. It is better observed in the vegetative world than it can be in the animal. The reproduction of life from the parent cells, and the physiological changes that the microscope reveal, are essentially alike in plants and in animals, and, from obvious reasons, are better discussed, as they have been here, in relation to the former. The analogy between the germination of a seed and the development of the bird from the egg may, however, be momentarily considered.

The process in the formation and growth from the germ is essentially the same in the viviparous as it is in the oviparous animal, yet it can be far better observed in the latter than it is possible to do in the former instance. A close analogy exists in many ways between the seed of a plant and the egg of an animal. As has been already stated, the greater portion of a seed, a grain of corn for instance, consists of material provided for the subsequent nourishment of the *germ*, which is microscopically small; starch, gluten, oil, mineral salts are stored in the grain in readiness for the demand the living germ will make when the conditions of warmth, air and moisture will awaken it from its sleep. A long sleep it may be, for the seed, wrapped in its tough, membraneous, outer skin, may preserve its potency of subsequent vitality unchanged for years (though not, as often falsely stated, from the time of the Pharaohs!). All the elements required for the young plant are present, and upon which, when in the ground, it draws and lives, until it enters the world above, fitted to find its own food from the air and soil.

A provision of essentially the same means towards the same end is made for the embryo bird. The fertilized egg of the barnyard fowl may be taken as an example of all eggs. It consists, as is well known, of the outer calcareous shell, of the thin lining membrane thereof, of the albumen or white of the egg and of the yolk, or the yellow oleo-albuminous central portion, both containing phosphorous and sulphur, as all protoplasm does. Most important of all, but occupying so little of the total weight and bulk as usually to escape notice, is the *germinative vesicle*, the actual, *living* egg itself; all the rest constituting merely the storehouse and provision for its growth and maintenance until it leaves the shell as a living bird. In the egg above named, on careful examination, there will be found, always on the upper surface of the yolk, a white, circular, disk-like spot; the Cicatricula, about one-quarter of an inch in diameter (.006 m), that is uncovered by the layer of vitelline or gelatinous albumen—the "white of the egg"—that surrounds it. A sort of canal, formed of the gelatinous vitelline, connects it with the centre of the yolk, in which there is a cavity. In the middle of the little disk is a small, membranous, somewhat lenticular, white body, from one-sixteenth to one-twelfth of an inch in diameter (.0015 to .002 m); it is transparent, and the surrounding margins have a radii-like structure. This is the fertilized germinative vesicle. *In it alone* is the potency of the future life. All the rest of the egg is to serve only for its protection and nourishment. At the centre of the larger end of the egg a small vacuous space is formed by the vitelline detaching itself from the shell and investing membrane. This space, which increases from day to day, is filled with air that enters through the pores of the shell. If kept in a cool place, at a temperature of, say, 40 to 60 degrees F., an egg will retain its properties for a number of days; it will also resist a low temperature. It has retained its vitality even when exposed to the cold of 10 degrees F. A fresh-laid egg has a specific gravity of 1,078 to 1,094. It loses daily 0.0018 in specific gravity, principally from the exhalation of carbon dioxide.

The process of incubation by which the simple cellular mass of plasmodium is converted into the living chick is simply the same process that takes place in the germination and growth of a seed, only that a higher temperature is requisite for its origin and continuance. When the hen has laid as many eggs as she can cover—usually about a dozen—an irresistible desire to "set" overcomes her. The sitting hen is in a curious, peculiar state. She seems to present all the symptoms of fever, her eyes are sparkling, her skin burning, she drinks more than she eats. To see her ardor one would say that she comprehends the importance of the function that she exercises. Buffon says: "But what is most remarkable is that the attitude of a sitting hen (une couveuse), however wearisome it may appear to us, is perhaps less a source of ennui than it is a state of continued enjoyment. The more delightful because it is inherited, for nature seems to have placed a charm in all that has relation to the multiplication of the species."

The temperature required for incubation is 105 degrees F., continued for twenty-one days. This is afforded by the animal heat of the sitting hen, but is equally effective if furnished from any other source, provided that the other necessary conditions of fresh air without excess of moisture are also present. The loss of weight during incubation is about twelve per cent., of which the greater part is due to the evaporation of water. The absorption of oxygen nearly compensates for the loss of carbon and hydrogen by oxidation, and exosmose of one portion of the plasmodium in raising the remainder to the higher organization of the living chick.

The progressive changes in the egg under the heat of incubation have been frequently studied. At the end of three hours the cicatricula has increased from .006 to .008 m, the transparent centre to .003 m.* In six hours the cicatricula had become .0085, the centre .0035. The embryo has a length of .001 m. In nine hours the cicatricula measures .009; the pellucid area .004 m. The shape more decidedly oval and a structural texture more evident. The embryo now is .0027 m in length and its marginal surroundings better defined. In sixteen hours the disk containing the embryo shows great change. The upper lateral surface is much contracted by becoming rounded, and the folds that the membrane has made in thus changing are bent back like a vail before the cephalic extremity of the embryo. Below, the sides form a concavity in the middle part, their margins coming together under an acute angle, comparable to the shape of a lance head, the embryo occupying the middle position. The groove that is to become the vertebral canal becomes distinguishable, and the latter soon after is formed. The cicatricula is now .016, the pellucid area .006 in diameter and the embryo .0055 m long. Three hours later it is .0065 m long. When the incubation has lasted for thirty hours the commencing formation of the principal organs—the heart, brain, etc.—can distinctly be seen. At this time a vascular network commences in the cicatricula. The blood divides itself to the right and left of the embryo into a plexus of capillaries, that gather finally into larger vessels that carry it above, or direct it below, whence it returns to the heart.

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* A Meter is about forty inches. A millemeter (.001) is approximately one twenty-fifth of an inch.

In forty-five or forty-six hours there may be seen towards the abdominal region of the chick a transparent membranous vesicle about the size of the head of a pin. This develops rapidly, spreads itself over the surface of the yolk, and finally invades the whole inner surface of the shell, to which it attaches itself. That portion of the vesicle which is in contact with the shell is abundantly provided with blood vessels, and it is evident that the blood which is sent thither is venous, whilst that which returns is arterial. It corresponds to the allantois and to the chorion in the mammalia. The amnion shows very clearly on the third day. It is evidently derived from a fold of the cicatricula, which envelops the chick after having formed the abdominal cavity. The development now progresses uniformly. The remainder of the yolk is found enclosed within the abdomen as soon as the latter is formed, and serves to nourish the chick for the first twenty-fours after the young bird has escaped from its shell. During incubation respiration takes place at first, as before stated, by absorption of oxygen through the air space that is found at the large end of the shell soon after it is laid. After two days' incubation the blood vessels that spread over the inside of the shell absorb directly by endosmose the oxygen that penetrates through the pores of the shell, the latter becoming more porous as the incubation progresses, the shell becoming more and more brittle proportionally, and at last is readily pierced by the beak of the bird.*

Thus within three weeks, under the influence of heat, moisture and oxygen, the mass of plasmodium constituting an almost undifferentiated cell—the new laid egg—rises from the condition of structureless protoplasm into that of a highly organized, living creature, with its wonderful apparatus for the circulation of blood, its ceaseless rythmic heart action, its power of locomotion, and, most wonderful of all, the faculties of sensation, perception and volition. It is no longer merely an organism, curiously and elaborately made, but subject utterly to the outside influence of foreign causes, or the controlling action of wind or weather, as plant life has been. It is an independent being, with its pains and pleasures, its fears and hopes, its likes and dislikes, its sorrows and its affections. The love and devotion that the mother-fowl shows in watching, caring for and defending her helpless brood has rendered her typical of a mother's love. The courage, fierceness and fortitude of the other parent, in his battle to the death with his feathered rivals, has made him as proverbial for his qualities, and yet these and all other manifestations of animal life laid dormant within its shell, without more than the potency of living, until the vivifying influence of the light and heat of the Ether for twenty-one days gave it life and woke it into being.

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*Pierre Larousse. T. XI. P. 1263.

The changes that we can readily observe in the growth of the bird within its shell almost from its first conception, are almost identically the same in the growth of the vivipara, but, of course, are hidden from our sight during the mother's life; the parent giving within itself, hour by hour, and day by day, the nourishment that is requisite, and that is prepared, as demanded, not from a storehouse provided in advance, as in the egg. With those born living the conversion of food into tissue and the oxidation of the carbohydrates and the nitrogenous albuminoids in the parent, elevate a portion into the higher plane of organization requisite for the existing life and for the new one forming; the phenomena of the growth of sensation, of consciousness, and of will, being equally as impossible to comprehend in the vivipara as it is with the ovipara.

The new-formed embryo, being the inheritor of the protoplasmic cell structure from each of its parents, inherits likewise their individual idiosyncrasies. As the adults can only have fertile offspring when they are closely allied in species and conformation, their young will usually represent very nearly the average of the breed from whence they have sprung. The tendency to resemble the inherited traits of one line of parentage more than that of another is dependent upon the conditions of relative adaptation of either parent structure to the needs of its existence, and the consequent development in its offspring of that form of structure that is *best* fitted for its life, rather than that of the other form. Thus are introduced variations in some of their descendants that give rise in time to so great changes that new species are formed. The details, causes and conditions thereof constitute the subject matter of Darwin's doctrine of the "Origin of Species," and of the higher evolutions of life by natural selection and by the "survival of the fittest."

CHAPTER XXIII

EVOLUTION OF LIFE—ORIGINAL MEANING—HUXLEY'S DEFINITION—PRECURSORS OF DARWIN—MONBODDO, LAMARCK—THE ORIGIN OF SPECIES.

THE phrase "Evolution of Life" had in the 18th Century a different meaning from that which it bears in the latter half of the 19th. To Bonnet, Malebranche, Leibnitz, as Philosophers, and to Malpeghi, and to many other naturalists, the question thereby suggested was, whether or not the germs of a new life contained within themselves the perfect plant or animal in miniature, and which subsequently evolved, or *unfolded itself*, into the growing life by merely a process of augmentation. Malebranche said: "God has formed in a single fly all those that will ever come from it." Thus, they argued, the germs, past, present and future, were shut up ("emboités, ou incasés") one within the other.

To this conception of the nature of the germ, Bonnet added another, which he thought equally plausible, viz.: that the germs of all beings (animal or plant) are widely disseminated in a partially developed state through the air and water, and will become alive when they fall into an organism similar to that from which they came; thus constituting all surrounding nature into a vast reservoir for their conservation. Opposed to the doctrine of evolution was that held by Buffon—"l'accolement." He imagined a primitive organic matter, distinct from inorganic matter, composed of living molecules, incorruptible and always active. These molecules, spread everywhere, served for nourishment and growth. When the growth is finished the overplus of molecules is sent from all parts of the body to a reservoir or special organ. Those which come from a given organism reciprocally attract each other, so as to produce a sort of miniature thereof. Thus the organs of the new beings are produced by the regular and harmonious accretions of the molecules in excess, and thus bear the impress of the parents.

These doctrines of evolution, as then understood, and of l'accolement, founded only on imagination, have given way to the third doctrine then held, of even older date than either, that of "Epigenesis," or that in which the germ is actually procreated by the parent plants or animals, not simply expanded or unfolded. It was held by Hippocrates of old, by Harvey, by Etienne Geoffrey Saint Hillaire, and is now the basis of modern evolution. It is purely the negation of the preceding hypotheses. It is merely a law or system that unites together the observed facts, not an explanation of the facts themselves. As now understood, Evolution is thus described by Huxley: He said: "Those who believe in the doctrine of Evolution—and I am of that number—find serious reasons for thinking that this world with all that is in it and on it, did not first appear with the conditions that now show themselves, nor with anything that at all approaches thereto. On the contrary, I believe that the conformation and the composition of the terrestrial crust, the distribution of land and water, the infinite varieties of plants and of animals that form its present population, are only the last terms of an immense series of changes, accomplished in the course of incalculable periods by the action of causes more or less like those that are at work to-day." Thus understood, Evolution embraces the geological theories of Lyell, and the doctrines of the "Origin of Species" of Darwin. It is generally understood by most men, *as it is by the writer of these pages*, that the process or processes called Evolution, whether in Cosmic or in living Forces, are indicative of the manner, or of the means, by which the existing conditions of the world and of the Life around us have arisen. They are not the *final* causes, but are the *efficient* causes only; the *method* by which the Higher Intelligence that rules the Universe has acted through natural laws. The Final, or *determinative*, cause of these, as of nearly every phenomenon, lies beyond the limits of all human faculties.

Among the writers of the Eighteenth Century who turned their attention to the relations between the lower animals and man, one of the earliest was James Burnett, Lord Monboddo, b. 1714; d. 1799, whose curious combinations of Aristotelian philosophy, classical learning and Orthodox religion, with credulous belief and original doctrines, excited the astonishment and ridicule alike of the learned and the unlearned world. An earnest adherent to the scholastic philosophy of the Middle Ages, and believer in the infinite superiority of all real knowledge as possessed by the ancient Greeks to that of the degenerate men of his own day, he rejected the Newtonian astronomy as being false and materialistic, if not atheistic. He accepted, however, the belief in Mermaids and Mermen, and considered as reasonably well-established by credible evidences, the existence of the men described by Strabo and mentioned by Othello—"Whose heads do grow beneath their shoulders." In contradiction to the general trend of his theories, he devoted a large part of his two voluminous works ("The Origin of Language," 6

Vols., Octavo, 1773; and "Ancient Metaphysics," 6 Vols., Quarto, 1779) to the advocacy of the doctrine that man is descended from the lower animals, and that the Ourang-outang (under which name he grouped a number of apes and the larger monkeys) was really the lowest form of—but nevertheless—a true man. This theory of the derivation of man especially excited the derision of all persons. Dr. Samuel Johnson, who was entertained in 1773 by Monboddo at his country seat in Scotland, and who shared with him the love for classical learning and metaphysics, with the like indifference to mathematics and the natural sciences, spoke of him as "A Scotch Judge who has lately written a strange book about the Origin of Language, in which he traces monkeys up to men, and says that in some countries the human species have tails, like other beasts." He attacked Lord Monboddo's strange speculations on the primitive state of human nature, saying to Boswell: "Sir, it is all conjecture about a thing useless, even were it known to be true. Knowledge of all kind is good; conjecture as to things is good; but conjectures as to what it would be useless to know, such as whether men went upon all-fours, is very idle." (Boswell; Johnson's "Journey to the Hebrides.") This inchoate form of an investigation by Monboddo into the descent of Man was devoid of scientific value from the absence of nearly all inductive evidence, and consisted mainly of inadequate a-priori reasoning, yet it was the only subject worthy of serious consideration in his voluminous pages, and will keep his name alive as one of the early pioneers into speculations that have since then changed the very basis of modern thought. His classical learning was useless to him; his metaphysics and philosophy were erroneous or worthless; but what Dr. Johnson and others thought were idle conjectures, contemptible and ridiculous, have proved to be premature glimpses by him, of the light to come nearly a century later.

In the development of the doctrine of Evolution, Jean Baptiste Pierre Antoine de Monet, Chevalier de Lamarck, Jesuit Student, soldier, Botanist, Chemist and Biologist, b. 1744; d. 1829, brought widely different faculties to the service of science. He was born at Bazentin in Picardie. When scarcely seventeen years old he escaped from the Jesusit College at Amiens, and joined the French army as a Volunteer on the eve of the battle of Wittinghausen against the allied armies of England and Prussia. His firmness and bravery were so strikingly shown that he was rewarded by being made a lieutenant, and as such distinguished himself in several engagements. Not long after, an injury accidentally received from a fellow-officer obliged him to leave the army. After a year's illness and consequent confinement, his necessities forced him to seek some other means of living. He determined to study medicine, supporting himself meanwhile by employment in a banker's office, his own inherited income not exceeding 400 francs. After four years' trial, not liking the practice of medicine, he abandoned himself exclusively to botany. After several years of study he published his "Flore Francaise," in which he introduced a new system of classification. Thanks to the approval and assistance of Buffon and of Cuvier, his work was very successful and had a rapid sale. He received a place in the Botanic Division of the Academie des Sciences. Buffon procured for him the position of Royal Botanist. With the son of Buffon, Lamarck visited the establishments and the learned men of Holland, Germany and Hungary. After his return to France, he contributed the section on Botany to the Encyclopædie-Methodique. He was appointed to take charge of the herbarium in the Cabinet of the Royal Gardens, which he held until the Revolution in 1792 broke up all the Societies of Savants. With this event his botanical labors ceased. The following year the Assembly reconstituted the establishment under the title of the Museum of Natural History, leaving the occupants of the places to choose among themselves the various new Chairs. Lamarck, being the youngest of the members, had to be contented with the least desirable of the positions—one that no one else wanted—that under which, according to the system of Linnæus, were classified the worms and insects. He had until then paid but little attention to any branch of Zoology, but he devoted himself with such assiduity to the new study that his work there stood on a higher level than even his botanical labors. To him is due the classification and the term of the "Invertebrata," which appropriately designates the distinguishing feature in these large classes of living beings. He depended upon Cuvier for the anatomical details, as he had no practical facility therein, but supplied the power of co-ordination and classification, in which Cuvier was often deficient.

It was unfortunate for the fame of Lamarck, even during his lifetime, that the speculative nature of his mind built theories upon insufficient or absolutely wanting foundations. With no practical or experimental knowledge of Chemistry, he attacked the doctrines and discoveries of Lavoisier, and attempted to overthrow by a-priori reasoning the facts carefully established by experiment. He also projected systems of geology, meteorology and of natural philosophy, all of which had the serious fault of not according with the known facts. The theory of spontaneous generation which he advocated, though since held in later days by many learned men, has now lost all support by the disproof of its empirical occurrence. He rendered to mankind the eminent service of arousing attention to the probability that all change in the organic, as well as in the inorganic, world was the result of law, and not of miraculous interposition. His theories of the origin of species were, that the organs of an animal were modified by the desires and will of the individual, in response to external conditions. The changes thus induced would be transmitted to their offspring, subject, moreover, to like changes from new conditions, so that, if illimitable time was granted, it would account for the formation of the highest order of animals from the lowest organisms. In accordance with this doctrine, he held that man himself was derived from the species next below him, the anthropoid apes. These, opinions openly and forcibly expressed, though received with general indignation and ridicule at the time, and for generations of those who came after him, now serve to make his name illustrious. They embody the same idea subsequently demonstrated by Darwin and by Wallace to be true, and now elaborated by them into the doctrine of Natural Selection.

Soon after Lamarck's appointment to his Zoological Chair his sight began to fail, so that he was obliged to depend upon the assistance of others for the observation of the structure of insects. In his later years he became absolutely blind. To this trial was added that of very limited means, his peculiar views on scientific subjects not making friends for him with those in authority. The devotion of his children to him compensated for many other deprivations. His eldest daughter especially, moved by filial love, for years gave her whole life to him, lending herself to the studies that could enable her to replace his want of sight, and writing from his dictation the greater part of his later works. As his infirmities increased and confined him to his chamber, she never left the house, "Feeling incommoded," she said, "by the open air, of which she had lost the usage." Such affection unfortunately is rare. It is no light eulogy upon the character of Lamarck that he inspired such love and devotion in his offspring.

To Charles (Robert) Darwin (b. at Shrewsbury, Eng., Nov. 12, 1809; d. April 19, 1882) is due the merit of placing upon the basis of scientific demonstration the theories and conjectures of many minds that had preceded him. He states: "The first whose conclusions excited much attention was Lamarck. Geoffry Saint Hillaire and many others have since then suggested the same or analogous ideas. They scarcely advanced, however, beyond conjectures." *

The doctrines that are embodied in what is known as Darwinism are:

1. The laws of *Natural Selection*, or the inheritance by plants or animals of the traits of ancestors, modified at times by such variations as may be of advantage to the young and growing organism, and which variations, if of benefit to the tribal order, may be transmitted by inheritance.

2. The law of the *Survival of the Fittest*, or the recognition of the struggle for existence, due to the constantly increasing number of plants and animals, while space for them, and food in, or on the soil, is limited. Those that are best fitted in strength and vital forces for the struggle, or those that undergo such modifications, either direct or indirect, as will give them an advantage over their competitors, will survive; the less fitted and weaker ones will die out. The offspring will therefore be from the strongest and best of their kind.

3. The Laws of *Sexual Selection*. Manifested apparently, only in the higher order of plants and animals, at least scarcely visible in the lowest. In animals this selection is often dependent upon physi-

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* Historical Sketch prefacing the first edition of the "Origin of Species."

cal strength only, as where the male overcomes, destroys or drives away his weaker rivals. Especially is this the case among polygynous animals, for instance—the ox family, deer, the fur seal, the domestic fowl, and many others. In other instances, especially among birds, an appeal seems to be made to an æsthetic sense, and as the *beautiful* is usually the exponent of health, strength and functional adaptation, the owner of the most brilliant plumage becomes the chosen one. With song birds the charm of their melody is equally effective.

Among plants it is only those whose flowers require fertilization by pollen carried to them by birds or insects that bear showy, brilliant petals. Those that have pollen brought to them by the wind are inconspicuous and colorless. With flowers, the birds and insects supply that consciousness and volition that the plants themselves are devoid of.

The above doctrines Darwin has established, not so much by experiments, for which the life of a man is too short, but by innumerable observations that he has made in both kingdoms of nature, and by the thousands of explanations he has given for peculiarities shown in animal and plant physiology and structure that are otherwise unintelligible. The occurrence of abortive organs, of useless structures, the facts of Embryology, of Atavism, and many heretofore inexplicable phenomena in organic life, up to and including that of man, find only here their satisfactory explanation.

In the doctrine of Natural Selection and Survival of the Fittest, the variations from inheritance that benefit the individual or its descendant are often produced by unconscious response to external conditions in the environment, sometimes too obscure to be recognized, and constitute then what are commonly called accidental changes, but in reality they are the result of established laws, only so deeply involved that they are not apparent to us.

In the case of sexual selection a new motive force is supplied. It necessarily requires conscious action and volition. These phenomena in the higher order of life are assumed to be present and efficient.

CHAPTER XXIV

THE BRAIN IN MAN AND ANIMALS—STRUCTURELESS, CONSCIOUS BEINGS—THE ORGANIC MECHANISM THE VEHICLE, NOT THE CAUSE, OF LIFE—POTENCY OF LIFE IN SEEDS UNINJURED BY EXTREME COLD.

THE intellect of man and the reasoning faculties of animals, whether thought to be differing in degree or differing in kind, are unquestionably alike dependent upon the organization and structure of the brain. An injury to almost any part thereof, whether in man or beast, disturbs or destroys the action of the senses and obliterates the memory. Pressure upon the substance of the brain renders the subject unconscious or insensible. In man, disease or fever perverts the reason, and delirium or insanity take the place of the intelligent mind. Narcotics or alcohol at first stimulate to overaction, then stupify the brain, and often establish a morbid habit that destroys the Will and the Moral Sense.

Anæsthetics deprive man or beast of sensation, consciousness and volition, leaving active only the unconscious vegetative life of the cerebellum, the cerebrum and its higher faculties being in a state of stupor. It is known that the grey matter of the brain is the seat of the mental operations, but how it acts, or what are the metamorpheses that take place, it is impossible even to conjecture.

It is the *mechanism* by which the Volition of the ULTIMATE POWER converts other forms of Energy into Sensation, Consciousness and Will. When the brain of various animals, successively lower in their organization, are examined, the convolutions of the cerebrum are found to be correspondingly fewer in number, simpler, and smoother on their surface. Descending still lower, the sensory ganglia alone are found, which, with the spinal cord, are sufficient for the functions of their life. With insects the cephalic ganglia control or direct the ganglia of the nervous system, giving rise to the reflex actions that mainly constitute—as Dr. Carpenter thinks—the manifestations of instinct, often so wonderfully developed in this class. Thus descending ever lower and lower in organic life, increasing simplicity in general structure is found, until the Amœba among animal life and the Myxomycetes among plant life are reached. They show consciousness, sensation and volition, low in degree, but in no respect different in kind from the faculties shown by others higher in the scale of life; yet these living creatures are almost, if not utterly, devoid of organs, structure, or any form; no *one portion differs from another;* all parts are *brain,* all *stomach,* all *limb;* all parts are sensitive and seek or avoid the light. If broken up or divided each fragment lives on a life of its own. They are simply formless, shapeless, gelatinous masses, but capable of self-movement, of seeking their food and converting it into their own substance. They have sensation, volition and perception. Like the germinal chlorophyll-holding cells of the Vaucheria Clavata, they are not merely lumps of plasmodium with the *potency* of life; they are *living creatures,* having received life from parent organisms, and in turn begetting others with the like or higher capacities than their own.

In observing the varied phenomena that nature offers in the many protean changes of energy from one form to that of another, such as the production of light, of heat, of galvanic or electric currents, there is a constant tendency to confound the *mechanism, contrivance,* or *means,* by which, or through which, the change occurs, with the *ultimate cause itself;* to lose sight of the pre-existing energy as the motive force, and thus to substitute *conditions* for *causes.* In the days of exclusive, a-priori, reasoning this was natural enough; indeed, was inevitable. The ringing bell was a sufficient reason for the sound that reached the human ear. The theory that the air vibrations alone affected the ear that heard the sound was considered foolishness and false, until, placing the ringing bell in the air·pump's vacuum, proved that where there was no air there could be no sound. There was a time when Sound did not exist on the earth—ere on its surface life appeared. When first cooled from its fiery glow, "The wreck of matter and the crush of worlds" undoubtedly gave origin to the contraction and expansion of the aerial spheres whose onward moving waves now carry Sound to the ear. But the waves then died unheard. No ear, animal or human, existed to transmit their impulse, and no brain to receive them. They would only be "Winds that withered in the stagnant air," or beat silently on the rocks and stones, for Sound is only Sound when heard by the subjective brain; in itself it is only an aerial impulse, signifying nothing.

The Electricity that was produced by rubbing pieces of amber was early observed by the Greeks. Homer in the "Odyssey," IV., 70, speaks of amber: "The flashing of gold and of amber, of silver and of ivory." The curious property it showed of attracting and repelling small light particles obtained its name—Electricity—from the Greek term for amber—"Electron." The legend being that in the Baltic Sea amber was produced by the tears shed by the daughters of the Sun God—one of whose names was Elektron—bewailing the loss of their brother, Phaœthon. Amber was the source of numberless fables, superstitions and romantic interests brought from the distant and almost unknown shores whence it came. The workmen who carved it were seized with strange, nervous twitchings in their hands and arms. It was thought to have a soul. Even to the present day the common people believe there is a charm in amber beads that will preserve infants from poison and from many ills.* The phenomenon was then sui generis; Electricity, otherwise unknown, was thought to be inherent in the nature of amber, and, as an occult force, was inexplicable. Its connection with lightning was not dreamed of. Nearly thirty centuries had to pass away before men knew that the force they felt and saw was in the ambient air and ether; amber was only the vehicle for its manifestation.

Optical phenomena offer many such instances. In the Middle Ages the rainbow was considered to be a miracle. The writer of Genesis ix. 14 states: "When there is a cloud over the earth the bow shall be seen in the cloud." The original Chaldea-Babylonian legend poetically describes it: "Afar off, approaching, the great Goddess raised the great zones which Anu made for their glory." By all men the objective existence of the rainbow was believed in. Descartes, at the suggestion of M. A. de Dominis,* further studied and established the true theory of the apparent position and shape of the bow. Newton's discovery of the prismatic colors completed the knowledge of the fact that it had a subjective existence only and relegated its phenomena to the study of "The Physics of the Ether."

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* T. Moore sings of "The loveliest amber that ever the sorrowing sea-bird has wept." The sisters of Meleager wept so bitterly over their brother's death that Artemis changed them into birds.

It is hard to realize in our consciousness, although we well know that it is the fact, that the beautiful colors of the world around us exist only on our retina, or in the nervous tissue of our brain. . The vibrations of the Ether carry the compound or white rays of light; they are broken up by objects around us, as they are in the raindrop, some absorbed and some reflected. The colored object seen has itself only the structural mechanism that separate the beam of white light into the colored rays, its components. The colors are in the Ether movements only; without them all objects in the world would be colorless and dark.

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* Marc Antoine de Dominis, a Jesuit priest, 1566–1624, was arrested for heresy and imprisoned in the Castle of St. Angelo, where he died a few months afterward. His trial was continued after his death by the Inquisition. He was convicted, his body disinterred and burned on the Campo dei Fiori, where Giordano Bruno had been burned alive twenty-five years before.

Thus should we look upon the phenomena of life: The living creature, plant or animal is a *mechanism* for transforming other forms of energy into that form called *Life.* In its lowest and simplest form, so far as our senses or our knowledge can inform us, the creature is without differentiation of parts or organs; is only a congeries of molecules, formed from a few chemical atoms: carbon, nitrogen, hydrogen, oxygen, sulphur and phosphorus, that make a substance called plasmodium, producable only by inheritance from a pre-existing, *similar*, *living creature.* It has not necessarily any structure or difference of parts within itself, but *has*, even in its simplest form, the potentiality or capacity of serving as the medium by which the energy of the Ether is transformed into new forms, among which are *sensation*, *consciousness* and *volition.*

The *potentiality* of life seems to exist physically apart from the *activity of life itself* in the spores of the lower forms, and even in the seeds of the higher plants. If kept dry and cool, the latter can be preserved unchanged for many years. The germs of many of the Bacteria will withstand uninjured a temperature somewhat above that of boiling water, and will afterwards develop into life under lower temperatures and favorable conditions with their peculiar and morbific properties unchanged. This persistence of life, or rather the continuance of the potentiality thereof, has been and is even yet the support of the adherents to the doctrine of Spontaneous Generation. They thought that in their experiments they had destroyed the *germs* of life in destroying *existing life* itself.

The after vitality of the seeds of even the higher plants when exposed to excessive cold has long been known. It is, though, only within the year—1898—that the availability of liquid air has made it possible to submit the seeds of barley, oats, peas, sunflower and other plants to the low temperature of —295°—313° F., or nearly 340 degrees below the freezing point of water; now—1902—even still lower, to that of solid hydrogen, within 24° F. of the absolute zero, with the same result.

Inasmuch as Life is an existence dependent upon certain changes of energy continually occurring in the organism of living plants or animals, the term *alive* is not logically or scientifically applicable to a structure wherein no change whatever of energy or of composition occurs for a very long and indefinite period.

These properties of withstanding the extremes of temperature by the germs of life that would be instantly fatal to life itself countenance the thought that, in plants at least, the structure of the *germ* consists of molecules of the chemical atoms united only by *simple chemical affinity*, such as exist in inorganic bodies, or in the derivatives of organic life, the glycerides, or some forms of the albuminoids. These latter, if anhydrous, would sustain no change if all the etherial vibrations called heat were withdrawn, even to the absolute zero, and would bear unharmed a temperature near to that of boiling water. The ultimate cell germ, though *not living itself*, retains unchanged for years and years its potentiality of responding to the etherial vibrations that convey heat and light, and that confer *then* upon the organic structure the mystery of life. The germs of animal life seem to possess, though in a lesser degree, the same dormant potentiality. In viviparous animals such persistence is of course unnecessary, since the conditions for life are ever present and never withdrawn. The eggs of the oviparous vertebrata possess their future food in the form of liquid albuminoids, that a temperature even far below the boiling point would harden and render useless. The necessary water for change of living structure and tissue formation is present in proper quantity from the beginning, and cannot be subsequently added to even if needed. Extreme cold that would solidify aqueous compounds by freezing must necessarily be destructive. It is remarkable, though, what low temperatures can be borne with impunity by the eggs even of birds, highly organized animals as they are. They will sustain without freezing and uninjured for some time a temperature but a few degrees above zero F. The experiment has not been tried, so far as is known, of testing the viability of the eggs of insects after subjection to the low temperature of liquid air. The farmers, however, in the Northwestern States of our country know by painful and costly experience that the eggs of caterpillars and other destructive scourges of vegetation readily survive the almost arctic weather of 30 to 50 degrees below zero F.

In plants, as already has been described, spontaneous motion occurs in the algæ and others of the lower orders; in the higher orders, with the exceptions noted, it is restricted to the circulation of the plasma in the tubular cells of the plants. In the lower orders the motion named presents every evidence of being caused by sensation, consciousness and volition; all limited and vague, but clearly demonstrable. The unnecessary substitution of the properties of the term chemie-taxia, proposed by Metchnikoff, for apparently the volitional motion of the Amœba, Bacteria and Leucocytes, only introduces a new, obscure and unknown cause of action of which we know absolutely nothing, to explain that of which we know something, though, it is true, not very much.

The processes of evolution have not increased in plants the development of what may be called the mental forces of nature. The tendency of the roots of growing plants towards water, the grasping of the tendrils of a vine for the support needed for its growth, the varied phenomena of florescence and reproduction, indicate no more of volition than the protococus or vaucheria have shown. The functions to be carried on in the plant world, that of preparing food, liberating oxygen, and of thus rendering animal life possible by their previous existence, need no addition of increased duties or higher faculties than we find plants gifted with.

The processes of *plant* life are essentially synthetical. They form from the inorganic molecules of the soil air and water, those compounds of carbon, hydrogen and other elements which, when reunited, make the plasmodium, tissues and fluids of cellular structures that constitute the food of animals. They give out to the air the oxygen they have set free from its chemical union with carbon and with hydrogen to become later the source of breathing for all animal life. On the other hand, the metamorphoses in the *animal* are essentially the opposite, the retrogressive and oxidizing, whereby one part of the tissues and substances formed in the animal from the food prepared by plant life runs down the plane of organization, forming again carbon dioxide and water, during which action the energy thus liberated raises other parts to the higher plane of life's phenomena, to the functional exercise of the various organs of the body, and to the manfestation of consciousness and will.

Thus the lowest forms of life—the Monera of Haeckle—have parted upon their separate paths. One form, whose destiny it is to become the plant, the food provider, the ultimate mother of energy to all who will have consciousness in life, will remain itself as little conscious, or even less so, than before. The other, whose paths will divide, redivide and subdivide again and again, on land, in water and in the air; to whom the mechanism has been or will be given in its brain to bring into being part of that energy as thought and will that existed in the source from whence all came; will lead a life of exertion, of care and trouble, of pleasure and of pain.

The course of evolution, from the lower creature to the higher one, requires the exercise of all the faculties. Hunger must be felt by animals and food must be sought for; at first an easy task, but as numbers increase more and more difficult. Starvation and disease would thin their numbers, but in doing so all would suffer and the race deteriorate. The introduction of the Carnivora saves from this end, and procures a rapid and easy death to some of them, that checks the increase without injury to the race surviving.

Ages pass away! Those descendants from the distant past in whom evolution has reached a permanent type best suited to their environment preserve their type unaltered. It is probable no change could improve the beauty of form, the strength of limb, or the speed and action of the horse; the combination of strength of wing and lightness of structure in the bird; or the fitness of the dolphin for the water in which it lives. Many creatures, vast in form and strength, that lived in times long gone exist no longer. Others have supplanted them, better fitted for their place. Modification of the muscles, internal organs and of outward form seem at last to have reached that point when change could not bring further improvement.

CHAPTER XXV

EVOLUTION OF MAN—HUXLEY'S VIEW—HAECKEL'S VIEW—LANGUAGE, WRITING, PRINTING—EVOLUTION AND EMBRYOLOGY—THE MANIFESTATION OF HIM IN WHOM WE LIVE AND MOVE AND HAVE OUR BEING.

THE course of evolution has been very slow. Hundreds of thousands of centuries have come and gone since our globe separated from the vaporous mass that then constituted the sun and the inner planets—thousands of centuries since the earth became cool enough to permit the first life in any form thereon. Then, as the earth grew older, plant and animal life rose higher and higher in their order of being, unchecked even by the glacial ages that for long periods drove all life far south of its former home.

Prior to this glacial era a change took place in the line of evolution. The bodily forms and functions, or what should be called the anatomy and physiology of life, had reached nearly the limit of present development, the construction of the organs in the highest order—the Mammalia—being then, as now, essentially the same in all. From some unknown parent form, so far as we know, now extinct, came several lines of descent; from some of them arose the anthropoid apes, the gorilla, ourang outang, etc.; from another branch Ancestral Man.

Huxley thinks this common ancestor was a Prosimian or Lemur, graniverous or frugivorous, and arboreal in its habits. The Lemurs are represented now only by a few forms found in some parts of Asia, Africa, Madagascar and the Sunda Islands. Haeckel does not go so far back for man's origin, and defines him as a "Decidual discoplacental, or catarrhine ape," with fur, and arboreal habits as before described.

The Simian or Ape-like descendants remained unchanged; they followed the general course of inheritance, and are now what practically they were then. It is seen from the above that Haeckel differs from Huxley in considering the true apes our direct ancestors, rather than that there was a common ancestor more remote, the anatomical structure of the placenta in apes, as it is in man, especially leading the former to that conclusion.

Be that as it may, the divergence of the two lines of descent became wider and wider. While the apes followed the laws of general heredity, with the usual occasional divergences therefrom, that gave rise to varieties and species among the Simian as among other families, their relative, the immediate ancestor of Man, experienced a change not only in the *degree* but in the *kind* of Evolution. When this time was it is, of course, impossible to say, but it is known to be within, if not before, the last glacial period. It is believed by many that man existed as man certainly as early as the pliocene period of the Tertiary. This period was thousands of centuries ago—a short time only in the infinitude of the past, but almost a past infinity compared to our own short, individual lives.

Haeckel considers man descended from one species, the catarrhine or thin-nosed apes, and believes Southern Asia was its native home. He thinks it not improbable that a continent then existed embracing Madagascar, the Sunda Isles, and approaching or joining the south of Asia and the southeastern shores of Africa. This possible continent, which he thought was man's probable birthplace, if it ever existed, is now sunk beneath the waters of the Indian Ocean. Here, he thought, might have been found fossilized the "Missing Link," the transition step between the highest ape and the lowest form of savage man. Geologically, this might be possible, for the age referred to, the Tertiary, was the time of the elevation of great mountain chains, in some parts of the north over 20,000 feet in height. As this wrinkling of the earth's crust has been caused by its contraction and doubling upwards in some places, thus forming the mountains, other corresponding depressions must occur in other places, involving a subsidence of extensive portions of land beneath the waters. Scientific investigation, however, has not confirmed his theory. No corroboration thereof has been found in deep-sea soundings that such a plateau or continent in the region described had ever existed.

The structural evolution of the body of man must have kept pace—pari passu—with such modification of his brain as enabled it to receive and respond to that higher form of energy that slowly raised its owner from the original level of brute consciousness and volition into that of the intelligence and will of the human being, even though that being was but a savage of the lowest type. Heretofore the prosperity of the individual animal and the continuance of its race depended mainly upon the perfection of its bodily organs, the strength or swiftness of limb or wing, and the general muscular force that enabled it to capture its prey or defend itself against the attack of others. The race then had been to the swift and the battle to the strong. The new line of evolution changed this. Man, naked, weak, and born without weapons of offence or defence, deteriorated, physically, in his merely brutal powers from those of his ancestors. He was forced to leave the shelter and safety of his arboreal existence by his increasing unfitness for that life and his greater adaptation for life on the open land. The very existence of his race was threatened, and seemed destined to be ended. With the greater intelligence that improvement in his brain made available, he learned how to keep himself from cold, to contrive means and implements to defend himself, to destroy his enemies and to kill his prey; for Man had become a carniverous, or, at least, an omniverous, animal, in place of living only on fruits, seeds, eggs and insects as his Simian or even Troglodyte relatives had done. The increase of brain probably needed more nitrogenous food to keep up its growth and develop its faculties. The discovery of the use of fire, and the way to obtain and preserve it, must have modified the course of his whole life.

To what extent the modification of the Simian type had taken place, and at what time relatively thereto the power of speech was evolved, is a problem upon which little light can be thrown. It is presumed that as nearly all the Simian race are gregarious (excepting the gorilla, which is polygamous only) they were able to communicate their wants in some manner to each other.

The Chimpanzees and ourang outangs, though more human-like in size, have less power of vocal utterance than the Gibbons; the Hylobates Lar possess loud and powerful voices, but their utterances are those of musical intervals, not articulate sounds. The efforts of R. L. Garner, N. Y., 1892, to interpret the vocal sounds made by the above species into language indicative of their emotions or their their wants, and to repeat the same to them again by means of the phonograph, have failed so far of success. The Hanuman (Semnopithecus) or Sacred Monkey of the Hindoos, as well as the Hylobates above-mentioned, though smaller and differing widely from the human form, yet possess a higher order of intelligence than those of the races Gorilla, Chimpanzee, etc., who outwardly nearer approach to man. In the Gorilla, especially, it would seem as if the process of evolution had expended itself in developing the perfection of muscular strength at the expense of all other physical and mental attributes.

With the development of speech the existence of true man (Homo Sapiens) began. Language at first probably consisted of ejaculations only, possibly such as his progenitors had possessed, but now used and understood in a definite and restricted sense.

The difficulty in using articulate language would lie in the capacity of the brain to co-ordinate the production of a certain sound with the identity of the thing or purpose desired; not merely in the capacity of the vocal organs or power of articulation. When this co-ordination of desire, will and utterance was once established, man could speak. The further perfection of language would be the work of practice and of time alone.

After the attainment of speech, countless centuries must again have passed away, even to times historic, before the art of writing was acquired. Many savage tribes are even yet without it. The Epics of War and of Mythology found vocal expression and long continuance of life in the cultivated memories of the Thracian poets, the Greek Rhapsodists, the Scalds of Scandinavia and the Bards of Cymri and of Bretagne. In these epics, transmitted orally and chanted or sung, the poetic form and rythm preserved with wonderful accuracy from generation to generation the memory of real or of imaginary deeds, until in long after years they were committed to writing. In this way a few of the brightest thoughts from the distant past have reached us: all else died with or soon after the brains that gave them birth.

When writing was perfected, and records of past thoughts and acts existed so as to be preserved indefinitely, the knowledge that the mind had acquired, no longer died with the memory of him who had possessed it. To the knowledge gained in one man's life, could now be added that which was best worth preserving, left by many of those who had gone before him. In this way the short span of life granted to man, has been extended both backward and forward, since he can learn from those who have long been dead, and can teach to others yet unborn.

The last four centuries have witnessed the discovery and the general practice of the art of printing; to this invention is due the wide dissemination of knowledge, and the subsequent downfall of much ignorance and superstition in Europe and in the Western World—beginning with the downfall of Scholasticism and the false philosopohy that it taught.

The evolution of the species of animals, through slight modifications of the laws of heredity, from the simplest non-structural plasmoid, to higher and higher organisms with increased functional capacities until Man is reached, has required hundreds of thousands of years. Strange as this procedure of evolution may seem to us, it finds strong corroboration and an analogy in the life-history of each individual animal, most strongly of all in that of man. Embryology teaches that human life begins, as all other life does, in the fertilized, almost microscopic, cell, without visible difference between it and the corresponding germ cell of other mammalia. This cell, at first about $\frac{1}{120}$ of an inch in diameter, as it grows, divides and redivides, as an amœba might do; then a grouping of these cells into a long, narrow disk that folds over into a tube-like shape, marks the commencement of the spinal marrow. The form thus made, the lowest vertebrate, the "Amphioxus," permanently retains. The further metamorphoses are essentially similar to those described in the hatching of a fowl's egg, the embryo as it matures passing successively through stages in which it is nearly undistinguishable from the embryo of a fish, tortoise, chicken, dog or other vertebrate in relatively the same stage of development. The length of embryonic life being so much longer in man than in the above-named vertebrates, the similarity referred to continues so much the longer in the advancing stages, in proportion to their nearer resemblance to him in their general structure. The birth of every man is thus a type of his evolution through long past ages.

When born, man, is of all animals, the least developed and the most helpless. Without even the power of moving, with less apparent intelligence than an Ascidian, he is dependent more than any other animal, for many months for life itself, absolutely, upon a mother's care. For more than a year he is less advanced than a puppy is when nine days old. He has entered this life with the *potency* of intellect only. His brain will slowly absorb with his breath and from his food the energy contained therein; the energy, reacting on its instrument the brain, may in time fit it to call forth the highest manifestations of this protean power that this world can know. Consciousness, perception and volition gradually appear, until, after the growth and education by the life around him, for nearly twenty years, the mental and physical development of the youth may be thought to be complete. He has individually passed through changes that his race required countless centuries to accomplish. But so long as man lives, if his life be well spent, until disease or old age prevents, his mental evolution may continue.

The progress of modern science, even as roughly sketched out in the preceding pages, has fully established the fact that the infinite range of phenomena, both in the inorganic and the organic world, are the manifestations of forces, working not by irregular, uncertain, or capricious acts, but by definite, certain and unchangeable laws. Under the same conditions and under the same forces the same results will always follow. It is further shown that the properties of all parts of nature, or what is called matter, are related in such a manner that they are subject to the same laws—that they are alike incapable of annihilation, or of being formed by man for nothing. The study of the manifold manifestations of energy, through whose action all phenomena appear, has shown that all are but the protean, or ever changing forms of one inscrutable, unknown power, everywhere existing, uncreatable and indestructible; without which there can be no motion, and which is the source and cause of all motion. Through it are produced and by it only exist what we know as Heat, Light, Electricity, Physical Motion, Chemical Action, Life in plants and in animals, Sensation, Consciousness and Volition. The intelligence that is manifested in the reason of man is brought by it, for beyond this power is the intelligence of the Omniscient that rules the Universe.

This protean Energy finds its simplest expression in the Cosmic Ether that penetrates this world and extends beyond the limits of the Stellar Universe. It is the carrier from the Sun to us of Heat, Light, Electricity, and of all the phenomena of Life. All we know of it, is what it brings to us. Of the absolute nature of the Energy in the Ether and in the Universe we know little or nothing. The VOLITION that is back of it and of other phenomena is only known to us as that FIRST CAUSE that is the origin and sustainer of all things; that has no limit in time or space; that is throughout the universe, and yet in all things and in all beings. It is through the Intelligence thus made manifest in His works that our finite and limited reason may hope, and does hope, better to know the source whence it came, the giver thereof, and of all good—to know that it is God!

CHAPTER XXVI

ALL ULTIMATE CAUSES INCOMPREHENSIBLE—UNKNOWN NATURE OF CHEMICAL AFFINITY—AN OVERRULING POWER, KNOWN IN ITS WORKS—THE MIND CONCEIVES ITS OWN SEMBLANCE ONLY—THE PROBLEMS OF SIN AND DEATH—THE ANSWER OF EVOLUTION.

It has been shown that in every phenomenon the final and ultimate nature of the energy involved, lies beyond the comprehension of the human mind. For instance, what is the action that constitutes Chemical Affinity? The ultimate atoms that are the subject of this force, and which constitute by their union our physical frames and all the varieties of matter, are they self-existing and essentially independent in their intrinsic nature? Are they the molecular groupings of one *primordial element*—of the *ultimate atoms of the Ether?* Or, finally, are they only the *centres of force*, without other existence than their own internal energies; that differ as the vibrations of the rays of light do, one from another, and thus varying in their expression of force manifest the affinities of each chemical substance? Many strange relations that are found to exist in Chemistry might find in the last surmise their explanation. The discoveries of Science are tending to break down the dividing barriers between Physics and Chemistry, throwing the two realms of energy into one. But the nature of the force—Chemical Affinity—under any view, is equally incomprehensible. The inherent nature of Matter, instead of being ignoble and degrading as Scholasticism taught, is thus shown to be as *transcendental* as that of the *mind itself*, to the human intelligence.

In the study of each phenomenon, of abstract existence, such as space, time, motion, energy and life, the limit of comprehension is soon reached; that borderland of thought beyond which every alternative that offers is alike unthinkable. The mind recoils, baffled as by an impenetrable cloud that veils the Inscrutable within. In all times and among all nations the existence of an *overruling power* has been acknowledged. That power, the Absolute, the Unconditioned, GOD, we can never know, at least not in this life, and of the life beyond we yet know nothing. The partial manifestations of his thoughts and deeds are before us to study and to know in the world around us. Our own mind or intellect is one of its highest objects of study, but it must be remembered that its faculties are limited—that it can do nothing and know nothing in regard to that which lies beyond its own limitations. It should be studied objectively—the workings of other men's minds rather than our own. The doctrine of Aristotle and of the Scholastics that "whatever is possible to exist does exist," led naturally to the consequent belief that "all that exists in thought must exist in fact," and gave to subjective suggestion an objective reality. The Metaphysician, believing that the idea of each and of all things existed before, beyond and apart from each thing itself, transferred the idea of the highest attributes of *human* intelligence and will to the idea of an Omnipotent and Omniscient Being, free from the limitations of power, space and time that restrict man, but otherwise in the *likeness of man.* To him and to the Theologian of old the Creator and Sustainer of all things was an anthropomorphic being, moved by the emotions that move man, and governing both in the phenomena of this world and in all that concerns man's welfare, temporal and eternal, in an inconstant, capricious and uncertain manner. The evils of life, whether physical, such as earthquakes, floods, tempests, plague, pestilence and famine; or personal sorrows, trials and death itself, were looked upon as punishments sent in revenge for national crimes or individual sins—the latter often having no connection with the evil, under which the guilty and the innocent alike suffered.

This idea of the Creator and Ruler of the world, though always anthropomorphic, differed in its attributes with the different minds that thought. Like the familiar, half-mythical Spectre of the Brocken, in the Hartz Mountains, each observer sees in the mists before him, an image, vague and indistinct, but superhuman in size and shape; yet to none is it the same. To one it may appear as a stern, austere figure, clad in the dark, scholastic robe of a Genevan Doctor; to another that of a barefooted, rope-girdled monk, and to a third that of a light and graceful image of innocent youth and beauty. Each sees only the projected shadow of himself. The first, sees only predestination and exacting justice; the second, abnegation of life's duties for monastic rule; the third, the promise of life and happiness now and the hope of the better life to come.

Our own thoughts and the thoughts of others can build up only what we and they have known—necessarily a copy on an enlarged or magnified scale of what we are. So long as men looked only into their own minds they could form an objective idea of God solely from their own ideas, subjectively considered. To view the Universe as an evidence of the nature of God, was looked upon as debasing bv the Metaphysician, and sacreligious by the Theologian. By most of them it is to-day still so considered.

The orthodox teaching of the Church has been, and is to-day, that Death entered the world in consequence of Sin. Even those that do not adhere to the acceptance, literally, of the myth of the temptation and fall of man, yet look upon Sin as an absolute existence that in some shape needs expiation, and upon Death as an unmeasurable evil that unnecessarily enters the world—that betrays a defect in the plan of creation, at least so far as man is concerned. They dream of a life that *should have been* here on earth, wherein Sin and Death might never enter. To them, and to most men, the existence of evil is incomprehensible. Why should the God of Love, Justice and Mercy permit pain and suffering to those who do no wrong, and why should sin, depravity and wickedness, riot through the world, rejoice and prosper at the expense of the innocent, rob them of their ownings and often of their life? If Omniscient, does He not know it? If Omnipotent, can He not prevent it? The Hebrew prophets and poets asked these questions. Their only answer was: It was the will of God; do good and avoid evil! The Zoroastrians believed in the dual principals; Ahura Mazda, the author of all good; Ahriman, the author of all evil. Early and Mediæval Christianity: in Original

Sin , or disobedience to God, to which was added a vivid belief in the personification of evil—the Devil. To all thinking men this question lies ever open and unanswered. The object of most religions is an attempt to answer it; of all, to point out a method to avoid the consequences of evil-doing and to obtain forgiveness for the evil done. It is not to be expected that man should ever fully comprehend all that these questions involve, still less presume to answer *why* God has thus done. All that man can do is to strive to know *what* has been done, and *how* it has been done. If it is only the *truth* that is sought for in every step of the search, the reason why, will sometimes also be disclosed.

If it is asked *why* God has made living creatures to suffer and to die, it may be said that God did not create the world or its animate creatures as man might create a watch. God is the life of the Universe, vast as it is, and lives himself, in part, in the life of each creature, and therefore *rejoices in its joys*, and *sorrows in its sorrow.* His laws, made for all, are for the good of all; but to the individual must unavoidably often give pain as well as pleasure. To the idealist, who from his own ideas projected, forms the idea of God, the Omniscient is also the Omnipotent, to whom the *impossible is possible*; who can by his fiat change all things at will. Science does not pretend to know what God can do or cannot do; but the observation of his works shows that he does not alter the workings of his laws. To believe that the order of existence should be different from what we know it is, because man's judgment might deem it better to be so, may be very natural; but it is the judgment and the wisdom of Ignorance. We know but little of life on this globe and nothing of life elsewhere. All we do know is that all things are governed by the struggle between opposite tendencies and forces that work for the general good; the power therein is limited *by its own acts*; that which is best to do has been done and *must* be done, though the individual may suffer.

He who is conversant with the phenomena of Nature, whoever has read the slight description in these pages of the Path of Evolution, must be conscious of the manner in which each phenomenon is interwoven with and dependent upon other phenomena of wider and deeper generalization. Thus one of the possibilities of life rests upon the indispensable presence of liquid water. This can exist as such only within narrow ranges of temperature, and, though it remains in mass unmoved from its ocean bed, is yet carried in vapor in the shape of clouds, that turn to rain, and is scattered over the thirsty land to give life's blood to the growing plants. By properties peculiar to it and different from those found in other fluids, when near the freezing point it becomes *lighter as it becomes colder*, so that the mass of *coldest* water keeps *near the surface*—becomes covered with a layer of ice lighter than itself—while the deeper water is heavier and several degrees warmer. If its properties a little below the freezing temperature were such as those of other fluids, most of the rivers and oceans near our land would freeze solid and never melt again, nor would clouds form, or rain fall on the dry and distant land. Many substances like Ice are lighter when solid than when fluid, and therefore float, but no other *liquid* than water becomes *lighter* as it becomes *colder*.

The relation existing between vegetable life and animal life, by which the former draws its subsistence from the inorganic world, from water, carbon dioxide and the soil, giving on the one hand the food that the animal must have but cannot make, on which it subsists, and on the other hand the oxygen, only by breathing which it lives. The Ether, bringing heat, light and life from the Sun; the properties of the air; the earth; our own frames wonderfully made—*all* show the work of an intelligence that rules throughout, making each detail a consistent part of *all*. No healthful and unprejudiced mind can fail to see thousands of instances of thought and purpose manifested everywhere.

The doctrine of Design—*Teleology, as it was formerly understood,* has met in late years with the disapproval of most scientific men. It was eagerly adopted by Metaphysicians, who, starting with the a-priori view of both Pagan and Sacred Writers that this globe was the centre of the Universe, around which all else moved, and the scene of man's immaculate creation, it was natural to suppose that man, though fallen, was still the great object for whose welfare all else was contrived. This was and is the Teleology of Theologians which Science does not accept. The progress of scientific knowledge—above all, the generally accepted doctrine of Evolution—has displaced man from his early eminence, and relegated him to his place in nature—merely the greatest, the most advanced member of a chain of beings, more or less like himself; each of which shows in its lineage the same evidence of intelligent volition and of wise purpose in its construction, that he himself can show.

THE TELEOLOGY OF SCIENCE is very different from that of the Metaphysician or the Theologian of old. Without any a-priori assumptions, it meets everywhere with the overwhelming evidence of an intelligence that has made and maintains *all* existence—the VOLITION that animates and moves THE UNIVERSE and all that is therein; not apart from nor outside of Nature, but in Nature, sustaining the life of each creature and each plant. The God of Science moves not in erratic changes of irruptive volition, but in established laws of wise prevision. To know and to obey these laws is to do right; to ignore or violate them is to do wrong. The consequences of wrong-doing follow, irrespective of the motive, and usually carry their own punishment.

It has pleased God to bring into existence conscious, sentient creatures. To those first formed, without organs or with simple and low organization, a low form of consciousness was given; the power of adaptation to better and more favorable conditions was bestowed, and with it the internal adjustment of their innate conformation in conformity thereto. Different traits inherited from their several parents induced various lines of development. Those that increased the functional capacity of certain organs, or made possible the higher development of the species into better forms, would be preserved, and would *continue still to improve;* those that retained the parental form in normal vigor would *continue unchanged;* those less fitted or unfit *would die out.* Thus the races would advance: those well fitted to lead a constant, self-adjusted life would continue as a species, in which the offspring would continue to reproduce the original parent traits, with but little change, for generation after generation. This condition would repeat itself indefinitely until slowly the numerous varieties of creatures that now exist were formed. This is the process of the Evolution of Life! The highest step therein is that which has given to the brain of man the ability to turn into *subjective thought* and distinct memory the *consciousness that is past.* In the lower brain of animals this ability scarcely, if ever, lived; but the unconscious record of inherited memories impressed thereon, became the instincts, that in them moved and governed, but knew not why, repeating without subjective thought the actions that their ancestors had often done before.*

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* The often repeated acts of their progenitors, producing by "co-association of the nerve cells, those reflex actions, partly conscious, partly involuntary in their descendants, that we name instincts." They are called into being by the stimulus offered by its hunger or by its other wants. This co-ordination of nerve cells, stimulus and reflex action had become hereditary.

W. Benthall, M. D.—Read before the Derby Medical Society. (From the Sci. Amer. Supt., Nov. 16, 1901.)

CHAPTER XXVII

YOUNG ANIMALS—INFANCY—CHILDHOOD—DISCIPLINE OF LIFE IN MAN, IN WOMAN—MENTAL DIFFERENCES IN SEX—SCHOPENHAUSER'S PESSIMISM.

THE question may arise, Is life to any Animal worth living? The simplest answer is, "It is, or why should it be given?" but this, it may be said, is merely "petitio principii." But who can look on the hordes of lower life, upon a swarm of gnats on a summer evening, at a flock of birds on the wing, to a number of animals of any kind, exulting in the power of motion, without seeing that they are rejoicing in life itself? As Monboddo said: "There can be no doubt that the brute creation have a greater pleasure in mere living, than the higher creature, man, can ever know."

All animals of the higher orders, including man, begin their lives alike. Born imperfect, weak and helpless, they are dependent upon their parents' care, at least for guidance to food, if not for the food itself;

for warmth, for shelter and protection. Depending thus upon a stronger and a wiser one than themselves, they are relieved in part or whole from the thought and care for the present moment and the immediate future that later in life await them. Their new-born energies surprise and delight them; to run, to leap, to exercise their muscles, is to play. At first the inherited records on their brain of acts oft repeated by their progenitors, unconsciously lead them in the guise of instinct to do what is best to do; the parents' example teaching them later as they are able to learn. Thus, in the exuberance of youthful blood, to eat, to sleep, to run and to play, to know no danger, feel no pain, to have no care or thought of the future, mere existence is perfect happiness! As they grow older the duties of life come on. The nearly adult animal has at first only itself to feed and to forage for, but anxiety, watchfulness and fatigue take the place of careless play. Its faculties are sharpened by avoiding danger or in seeking its prey. Mere pleasure has to yield its place to duty that carries pleasure with it—at first in caring for itself, and later in caring for others. A new happiness comes with the latter—the love for its offspring.

Our own childhood is much the same as that of other animals. For the first year the child has but little consciousness of aught beyond a vegetative life. Its utter helplessness, its inability to move about, to express any want or feeling otherwise than by cries expressive of discomfort arising from pain or hunger, make it absolutely dependent upon the mother's care. During this period it is probably not conscious of more than a vague feeling of comfort and satisfaction if it is well and its wants attended to, or of equally vague sensations of discomfort if the conditions are otherwise. About the beginning of the second year a great change occurs; the evidences of the mind higher in intelligence than those of the other mammalia now begin to manifest themselves. The boy recognizes persons, shows that he understands in part when spoken to, manifests the same pleasure in moving his limbs, and later in moving about, that all young animals share. With his growth comes the power of walking and running; with that of speech the establishment of the faculty that distinguishes man from other animals, and raises him into the world of his own.

The next four years of the child are like those of the young of the higher mammalia: as they do, so he rejoices in the exercise of his bodily and muscular faculties. He delights in running, jumping and frolicking, in the same manner and for the same cause that the lambs and kittens do, and as they are so is he, free from care or thought of the morrow. Every passing moment gives him a lesson from the world around him, which he learns unconsciously. No tasks are set him, and, his mind expanding, seeks to know and greedily drinks in all that stimulates rather than satisfies his curiosity. When six or seven years old, before he undergoes the discipline of school, a healthful and properly brought up child probably enjoys the perfection of animal happiness: not only the strictly animal functions are rejoicing in their appropriate exercise, but his awakening mind, becoming conscious of the objective world around him, looks down a thousand vistas that open before him, all offering hopes and pleasures to his view. His dependence upon those that care for him and from whom he receives only loving kindness, teaches him to love in return; his affection prompts him to seek for companionship and sympathy where he is sure to find it. He is conscious of his helplessness, and flies for love, comfort and protection to her who so gladly gives them. With him health is happiness: thus a little fellow of these early years, coming, as on every morning, into his mother's room crowing with joyful noise, was asked why he made those queer little sounds: "Oh, I am so happy I don't know what to do; I feel as if I *must* scream out loud because I am so happy!" This is the very happiness of life itself, in which the lower life of other creatures participates, perhaps surpasses us, in its enjoyment.

With his advancing age the boy's pleasure in mere animal life lessens. His school days begin; the duties of life claim his time, and confine him more or less to stated hours and away from his games and plays. The impulse to muscular exertion and contests of bodily strength, partly in friendly, partly in hostile strife, take the place of more childish play; the culture of his mental powers occupies increasingly his time and thought; his duties become more and more onerous, but with the healthy brain and body he learns a new pleasure—that of overcoming difficulties and of surmounting the heights that are hard to climb.

The ambition to succeed in whatever he undertakes is now stronger felt. As his bodily frame increases so do his mental forces. The discipline of life begins. The paths of life, on some of which his course must run, will now lie open before him; they should not be, and seldom are, quite smooth. He must choose what he shall do. If his means of living are from day to day, he must seek for work such as he can find; if in better circumstances, he must seek for such work as he is best fitted for. To all, to even the young millionaire, the duty of considering

"What shall my life be?" is equally imperative. If health and strength are given—and often even when they are not—he can to a great extent make his life as he wishes it to be. The pleasures of life must then lie in the fulfilment of its duties. The mere animal pleasures thereof must be relegated to the past he has left behind.

Most of us succeed in what we try for. The youth who only seeks for happiness in the pleasures of even innocent sport, who delights in hunting, in horses, in social joys, to the neglect of the duty of improving his mind and of providing for the future, or does so perfunctorily, gains often what he strives for; but he gains that only. He finds when too late that neglected duties cannot be reassumed at will, and that the openings to his success in life are closed forever. He, on the other hand, who hopes for happiness in the fulfilment of his duties, and places pleasure secondary thereto, looks to the future, and willingly gives up for its sake the passing joys of the moment, which can only be taken by sacrificing something else that should be done. As in all other things, the force of habit asserts itself; the sense of duty grows stronger and the temptation to forsake it grows weaker. Pleasures of a better sort are found, and the hopes of the past become realized in the results of the early living present.

For the first few years the young girl's life does not differ materially from that of the boy. The same desire for bodily exertion and for constant motion; the same manifestation of the joy of living are shown in each. As the intellect opens, the inherited memories from the parent whose physical conformation she reproduces, manifest themselves. As her muscular strength is less, her sports and games are gentler, too. The instinctive love for dress and adornment replaces that of the boy for mimic war. Dolls give her the delight that the drum and the toy gun give to her brother. The years advance more quickly with her. At thirteen or fourteen she abandons the ruder plays she has shared with him; the culture of her personal graces, which she had given little or no attention to, now absorb her time and thoughts. She is quick to learn and often ambitious to excel. Less apt to be drawn aside by outside distractions, she would frequently outspeed her brother in his studies for the next few years, were it not that so much time is often taken to acquire accomplishments that room is not left either in hours or in mental training for the sterner work that he has to do. Meanwhile her growth advances; in two or three years more her figure reaches its full height and its full development. Her mind and faculties likewise mature. In character she is more impressionable than he, more emotional, and guided by the affections, unconscious instincts and feelings, rather than by a sense of justice or cold critical judgment. While the youth remains still a boy, undeveloped yet for several years, in mind as well as in body, she becomes a perfect woman—lovely in form and feature; admirable in her intuitive impressions and opinions; clear in intellect; sympathetic, gentle and loving in her emotions and her ministrations. Such is what God intended a woman should be. Such is what many a woman is.

The occupations and duties of later life being dissimilar in the two sexes, the evolution of their mental characteristics must vary likewise. Nature prompts each sex to consider admirable in the other that wherein it most differs from its own. Woman, knowing her physical weakness—her dependence for protection and support upon a stronger arm than her own; perhaps guided by a dim memory inherited from an ancestry long past, when animal strength was all in all—looks for care and protection approvingly upon him whose manly form is the exponent of health and strength. When to these are added the proper bearing, indicative of the boldness and courage that a man should have, the outward requisites are given that a woman seeks. When still very young many women ask for nothing more, their imagination clothing the favored one with ideal virtues and qualities never possessed. If not counterbalanced in him by vices or cruelty, a love thus lightly won may often last through a long life; domestic ties, the force of habit and interests in common, filling up the gaps in deficient character that a thorough acquaintance must reveal.

With women of mature age or better minds the merely physical and outward traits are not all sufficient; they value most, often unconsciously, the *mental* characteristics that distinguish the man from that of her own sex. Not so much the cultivated intellect, the learned, well-read and original thinker, as he whose manner is indicative of a reserve force, of the power to control others and to command himself. If she is a thorough woman, she gladly recognizes in him qualities that may be deficient in herself. She should honor and esteem before she begins to love.

In the complex civilization in which we live many other motives influence her choice. Wealth and Position are forces in themselves that replace the natural ones that a simpler life would offer. The charm of novelty and the interest thereby excited in a new acquaintance, together with the inborn desire of pleasing and of successful rivalry, are often the determining causes in love affairs that a more intimate knowledge would have dissuaded from. In such cases the prospect for mutual happiness at best can be but doubtful.

As with the woman, the manly attributes are those that are attractive to her; so man is captivated by the feminine virtues, and often even by its defects. The very difference between their characters—that which pleases her in him—would repel, if not disgust, him if visible in her. Most women well know this, and often seek to please and captivate by manifesting their feminine helplessness and their want of courage and of strength. The greater liberty that he possesses in seeking her whom he may prefer usually makes her dependent upon the evidences of his preference before she can manifest her own. As the ultimate disposal of herself is in her own hands, she does not fail to exert her art of pleasing, and at times leads him on by an apparent interest that he mistakes for real, until the avowal of his feelings proves her success. This is often met with little consideration for the disappointment caused. In the nature of the relation of the respective sexes this is not entirely avoidable, for she does not always know herself or her own feelings until his action calls for a decision. Too often, though, she is throughout perfectly sure that it is "Love's labor lost," and rather enjoys than regrets his ultimate discomfiture.

These actions, together with the thousand little evasions, deceptions and false pretences that custom, modesty and decorum almost unavoidably force upon a woman's life, unfortunately, often tend to make many women less regardful of the inviolability of truth in little things and less conscious of its value. Though undeserving of the terms in which that apostle of Pessimism, "Schopenhauer," speaks, such behavior has influenced many minds to think and to judge disparagingly of her.[*]

Schopenhauer led a very free, dissolute life; when twenty-six years old he quarrelled with his mother (an authoress of culture and ability) for no fault on her part. He even refused ever again to see her before her death, twenty-four years later. He formed his estimate of women only from those of low degree. He would not even grant to their sex personal beauty.[†]

There may be, perhaps, some little truth in what he says, but the bitterness of his pessimism poisons all it touches. Neither woman nor man is without faults, in each sex peculiar to its own. We all bear around us more or less of the crysalis state of life from which we have in part emerged. The wisest and the best of us know it, and strive that in and from our lives there may be evolved higher and better ones, bearing less and less of the lower forms from which we have come. To value and to praise the beauty that graces the female nature, in its frame, in its moral and in its mental attributes, is the duty as well as the happiness of man. It is only the morbid and diseased diathesis that finds fault with the qualities—varied from those of man—that are given to her sex for the duties required, and which are so varied because they *must* be different from those of men.

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[*] "Women believe," he says, "Wir sind berechtigt die zu hintergehen, welche dadurch das sie fur uns, das Individuum spärlich sorgen, ein recht über die Species erlangt zu haben vermeinen. . . . Die Verstellung ist ihr daher angeboren, deshalb auch fast so sehr dem dummen wie dem klugen Weibe eigen. Darum ist ein ganz wahrhaftig unverstelltes Weib vielleicht unmöglich. Eben deshalb durchschauen sie fremde Verstellung so leicht, das es nicht rathsam ist, ihnen gegenüber, es damit zu versuchen. Aus dem aufgestellten Grundfehler und seinen Beigaben entspricht aber Falschheit Treulösigkeit, Verrath, Undank. U. S. W."

[†] He calls them "Das niedrig gewachsene, schmal schulterige, breithüftige und Kurzbeinige Geschlecht, das schöne nennen könnte nur der vom Geschlechtstrieb umneblte männliche Intellect; in diesem Triebe nämlich, steckt seine ganze Schönheit." (Über die Weiber Sec. 379–383.)

CHAPTER XXVIII

YOUTHFUL LOVE—MARRIAGE—A MOTHER'S LOVE—THE LESSONS OF LIFE—THE DUTY OF LEARNING THE PSYCHICAL AND MORAL LAWS.

"Und herrlich, in der Jugend Prangen,
Wie ein Gebild aus Himmelshöhn,
Mit züchtigen, verschämten Wangen
Sieht er die Jungfrau vor sich stehen.
Errötend folgt er ihren Spuren
Und ist von ihrem Gruss beglückt,
Das Schönste sucht er auf den Fluren,
Womit er seine Liebe schmückt.
O zarte Sehnsucht, süsses Hoffen!
Der ersten Liebe goldne Zeit!
Das Auge sieht den Himmel offen,
Es schwelgt das Herz in Seligkeit.
O, dass sie ewig grünen bliebe
Die schöne Zeit der jungen Liebe!"

OF all the motives that influence our lives none are so potent and widespread in their action as that caused by the difference of sex and the emotion that springs therefrom. Having its basis in the instincts that we share with all other breathing creatures, it rises above them in proportion as our nature is a higher and a better one than theirs. Stronger in its impulses in the young man than in the maiden, it is often the stimulus to ambition—the source from which he builds his hopes for the future. It holds before him as the goal to reach, the prize to strive for, the image that to him is graced with the beauty of an angel and the virtues of a saint. "To him there was but one beloved face on earth, and that was shining on him." Very often this early love languishes and dies without response and even without revealment; but if his dream lasts long enough, and the awakening be not too rude, his whole life may bear its influence for good. Other and better placed affections may come in later life; but the impress made by life's first emotion, often is never quite effaced.

Sir Henry Maudsley says: "If we were to go on to follow the development of the sexual instinct to its highest reach, we should not fail to discover a great range of operation; for we might trace its influence in the highest feelings of mankind, social, moral and religious. With the deprivation of sexual feeling goes the mental growth and energy which it inspires, directly, or indirectly. How much that is it would be hard to say; but were man deprived of the instinct and of all that mentally springs from it, it is probable that most of the poetry, and perhaps all the moral feeling, would be cut out of his life." (The Physiology of Mind, p. 372.) The subject matter of all romances, of nearly all the dramas of real life, as well as those of fiction, is this passion. It has been called an episode only in the life of man, but the very life itself of woman. Less demonstrative, because her role is the more passive one—to be sought rather than to seek—it holds her under its reign with equal force, and she returns with equal happiness the love she has inspired.

With the departure from the parental home the new phase of life begins. All through the past the maiden has had few duties to others than herself. Her days have been spent, though she scarcely knows it, much as other young animals spend theirs: in frolicking over the sunny meadows and green pathways that lie before them, with little care for the moment, and thoughtless confidence in the future. She has now to think for and care for, another than herself. The attention and devotion that the lover gave unremittingly, is replaced by the calmer and milder affection of the husband, who, returning to his daily duties and habits, now has other thoughts and finds other occupation also. With each of them, the rose-tinted aurora of love's early day, passes into the clearer but less poetic morning of every-day life. With the latter, come the vexations, the trials and the troubles that fall to the lot of all. Happy they who have not been moved to marriage only by mere outward charms or by wild gusts of passion, but by love and affection founded on respest, esteem and that knowledge of each other that will leave but little to be discovered in the better knowledge that the new life will bring. Some disappointments must be looked for. None of us can be so perfect that the balance of our temper, or of our disposition, does not preponderate to one side or to the other; whichever way it may lean may be a defect. Such little failings are often more trying than those of greater moment. The character of each must be learned anew by the other. Most fortunate are they whose only faults are thus trivial; but from such causes it is said the first year of marriage is often the least happy one of all. The graver faults, if any, are more liable to be due to the man; the lighter ones to the woman, who is more apt to be irritable and sometimes unreasonable. The change to her is a greater one, and trifling annoyances at times are hard to bear. He should ever remember as Prior writes: "Be to her virtues very kind; be to her faults a little blind."

Among the many previsions manifested for the welfare of man, none can conduce so much thereto as when two lives are happily joined as Man and Wife. Although in this connection, as in all else dependent upon human action, the union formed may prove unhappy—may have been entered on with little thought or care for the duties due from and to each other, and disappointment and unhappiness be the logical result—yet most often, the love that mutually began in youth grows stronger with each passing year.

In no other relation can be together joined the intelligent and cultivated mind, "that knows us better than we know ourselves:" the Intuition that so often wisely counsels or dissuades; the careful guardian of our home and all within it; the gentle companion, whose love, sympathy and interest share in all the pleasures and the sorrows of our life. Our children's lives grow away from us. Our past and their future can have little in common; our nearest friends, still less. But he who is blessed with such a wife should truly thank God for the greatest of all His gifts, for the very sunlight of his existence!

When, with the flight of time, her children come upon the scene, the earnest cares of life come with them. It is now her part to feel for them that love that in her infancy had been lavished on her. Until now she scarcely felt and surely never valued fully, the parents' fears, the hopes, the nights and days of anxious watching, the deep affection that gives so much and asks so little.

Our beginning, infancy, is identical with the unconscious life of the lowest orders. Scarcely higher than the vegetative plane, it is dependent, absolutely for all but breath, upon a mother's care. All adult animals find their greatest happiness in those days when their whole time and thought are given to the helpless ones they love. The bird, hastening to its nest with food for its young; the hen, busy with her little brood; the patient mother, with her kittens sprawling over her as she lies—all attest the tender feeling that animates her who protects and loves the little ones, and to whose care they have been given. To her comes also the greatest happiness this world can give—the love of the young mother for her child: unselfish, untiring, delighting in the fulfilment of the duties now imposed, the inborn instincts inherited by her, in common with the mothers of most other creatures, rejoices in the young life given, and for its defense and preservation would willingly venture her own!

It is for this reason that woman's nature differs from that of man. For her, the duty above all things else, is to defend and guard the helpless beings in her charge. For the mothers, in all the long line of ancestral evolution through which she came, have had this task. It was not their duty and it is not hers to consider the rights of others—to give to others that which is justly due them. For her the outside world is as nothing when the welfare of her young children is in question. The races of the world may perish rather than that one of her little ones should be harmed. Her intuitive good sense, her affection and her kindness will often guide her rightly through life; her sense of justice never will; for in her it should scarcely have and seldom has an existence.

Thus alike for man and woman the lessons of life are learned. The state of infancy and of immaturity continue much longer with man than with the lower animals, in proportion to their respective term of years. In the lessons taught in the long infancy the teacher learns as well as teaches. The affection, unselfishness and solicitude with which the child has been brought up, react upon the parent, and extend their guiding influence on his feelings and actions into a wider circle than that in which they originated, and form abstract ideas of the wise and good which in earlier days he did not have. In this way alone the parent is often rewarded. The stream of affection runs downward!—the child too frequently taking as a matter of course, with little sense of gratitude, all that has been done for him for a score of years or more. Not until he becomes a parent himself does he begin to recognize how much has been given him in days long past.

Life offers many problems that are hard to solve, very many that cannot be solved. The best that we can do is to look upon the world, not as we think it might have been made, but as it really is; to seek to know the laws that govern it; to understand how they act, and why they act, and, when we obtain the knowledge thereof, to yield willing obedience to the power that cannot be controverted. In this regard the moral and psychical laws are like the physical, though the former laws are not so easily learned. In regard to the latter the child, before it can walk, learns that it must avoid certain acts and leave certain things untouched, or it will suffer pain in consequence. All men know that the laws of gravitation are no respecter of persons. No amount of piety, innocence or virtue will save from destruction one who, carelessly approaching, falls from a precipice. The over-venturesome swimmer, when his strength gives out, will be drowned, whether he be a saint or a sinner. Even the zealous physician, who devotes himself to science, and for the benefit of it and of his fellow-men searches out the cause and the possible cure of a virulent disease, if not very watchful, may fall, and often does fall, a victim to deficient caution. Many dangers cannot be averted, but very many can. The laws that govern mental and moral acts are equally positive and equally inflexible. They are not so self-evident and self-asserting as those that are called the physical laws, but all who care can read them, and if wise obey them. The unpardonable sin is that ignorance that cares not to know and will not learn.

CHAPTER XXIX

ATAVISM AND CRIME—UTTER SELFISHNESS—BRUTALITY—PUNISHMENT SHOULD BE DETERRENT AND PREVENTIVE, NOT REVENGEFUL.

It was stated before that the question why Sin should exist in the world has been ever asked and is ever still unanswered. The churches, Catholic and Protestant, fail to answer, though each provides a remedy to avoid the punishment thereof: the one repentance and the Church; the other repentance and faith. Each leaves unanswered: "Why was man permitted to sin?" Modern science does not pretend to know much more than the churches, but believes it can throw some light thereon.

The dogma that Sin existed on the earth before Death, and that the latter came in consequence thereof as its punishment, is not supported by historic truth. Death existed thousands of centuries before man; it is clearly evident that it is as essential a part of the economy of nature as birth itself. Life could not have existed as this world was and is without it. The certain ending within an allotted time of every individual life, great or small, is as fully under the prevision of wise laws as the replacement thereof by the birth of a new, young and vigorous life that is lent us for a little while; then, too, returns whence it was sent. Death was intended to come and must come. Where the action of life's forces has been perfect and their operation unimpeded by accidental causes, the threescore years and ten for man, or the longer limit of fourscore years, should generally be passed. That it is not so, is frequently due to our ignorance, our own fault, or the fault of those whose lives are our inheritance.

The philosophy of evolution teaches that while the qualities inherited from their immediate ancestors are usually reproduced in the offspring, *Atavism*, or a reversion to the characteristics of some ancestor in the far distant past, quite frequently appears. This reversion is not necessarily an injury; it may reproduce the traits of a certain line of ancestors that were better in some respects, than those shown on the average by the more immediate progenitors; but, on the other hand, an inferior type may appear. The latter is more frequently the case, for since both natural and sexual selection have tended to advance the race, atavism would most probably lead back to conditions less favorable than those now existing. A less healthful body or brain, would be more likely than the stronger and better one, to be the object of reversion. In this manner the habits of mind of the savages of early ages at times reappear in their late descendants; even the almost feral lives that once were led, come before us like Vampires * from their far off graves. What are called monstrosities, are those unfortunate creatures among animals in whose antenatal growth some obstruction or malposition has sent into the world deficient in conformation, or joining in distorted structure two bodies partly into one. So also are born persons whose brains and mental forces are more or less deformed, not in the manner that all

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* Belief in the Vampire Superstition, though long before existing, spread in the early part of the 17th Century like an epidemic, from Moravia, Hungary and Poland throughout all Northern Europe, where it still exists. In West Prussia and in Pomerania as late as 1871 numerous lawsuits arose in consequence thereof. It is believed that the ghost rises from the graves where certain dead are buried, visits people in their sleep, especially those of its own family, sucks their blood, so that, after repeated visits, they sicken and die. Those who have been thus attacked and have died, become themselves Vampires and cause other deaths. On opening the grave of a Vampire the body, though long interred, appears like a fresh corpse, ruddy and filled with blood. No exorcism or priestly rites are of avail. The nocturnal visits will continue until the corpse is disinterred, the head cut off and a wooden stake driven through the body. Cremation is also effectual. (See Dissertations sur les Revenants, par R. P. Dom Augustin Calmet. P. 273. Paris, 1746, also Meyer's Kon. Lex., 1897.)

The name applied to certain large bats which are thought to suck the blood of sleeping persons is borrowed from this gruesome superstition. The word itself is of Servian origin.

recognize as disease or insanity, but such as in whom a *moral* distortion occurs. As the insane show their mental disease by their inability to reason rightly, so these latter show their moral disease in their incapacity to act rightly. Such traits are often the direct inheritance from their parents; often, though, they come from far off ancestors, and appear, as it were, sporadically in one member of a family only, in which neither parents nor the other children manifest such faults. The form in which it oftenest appears is the partial or total absence of the sense of Duty; of that feeling of obligation that impels its possessor to a given action or rule of conduct because he *ought* to do so, not merely for the sake of gain, from the desire for pleasure, or to please others. This feeling of duty can be made stronger or kept alive by practice, or it may be allowed to die out by neglect. With some persons it seems never to have existed, nor can it be made to grow anew. It is nearly identical with what is known as conscience. To those born with it, to have done wrong is to suffer painfully. To those who have it not, it is only chance or opportunity that makes them or keeps them from being criminals.

Another inheritance from atavism is that condition which expresses itself as over-selfishness. In the stages of man's early life, self-preservation and the care of his own was his first duty. As civilization advanced, the need of considering the wants and rights of those near and around him was forced upon him: he learned also that it was wise to take thought for the morrow, to lay up provision for the future, and to deny himself an immediate pleasure for the sake of avoiding a future ill. Thus he learned self-restraint in his conduct to others, thoughtfulness for others, and finally the wish and the power to control himself in the present and in the immediate future, in the hope of a greater good in a far off time to come. This mode of thought and action is still selfishness, but it is an enlightened selfishness that, although acting for itself, considers and takes care of the interest of others. Joined with the sense of duty before named, they form together the mainsprings to a proper life.

The victim of atavism without the feeling of the obligation of duty, has only the primitive selfishness of the savage life. Too indolent to work honestly, he supplies himself with what he needs by appropriating, as his far off ancestors did—by cunning or by open violence—the goods of others. If well placed in life, he contrives means of helping himself by secret participation in illegal contracts, by misappropriating funds, by buying up and selling out railroads to their ruin, or the thousand and one ways in which unscrupulous men enrich themselves to the detriment of others. The more lowly scoundrel carries his selfishness still further. For the present pleasure or the moment's gain he throws away the morrow's future. He will not or cannot work, but will lie, cheat, steal, or even murder, for a pittance that a week's honest work would have supplied. His selfishness is even greater to himself than to all others, unless it be to some unhappy woman that he may have in his power, whom he ill-treats and may finally murder. Drink, which reveals his worst but his true character, really maddens him.

At times reappear the traits of a lower life even than a human life—that of a savage beast; like the wolf, he delights in blood; even in childhood he slays his playmates to enjoy their sufferings and his own excitement. Yet this is not insanity; it is only the extreme type of a reversion to the brutal instincts, that are like the malformed, brute-like features sometimes born; he is a *moral* monstrosity, as the other is a *physical* one. Happily for the race of man this form of atavism is of rare occurrence.

The character formed by heredity can usually be made better or be made worse by its possessor, as he may choose. Ambition to excel may guide him one way, or the love of Pleasure lead the other. The ways of life are not intended to be always smooth and pleasant. The rougher the path, the more obstacles to overcome or to be avoided; so much the greater is the need of continued effort to advance; so much the greater must be the stimulus to call forth the strength and the abilities of the wayfarer. Experience has shown that where exertion is not compulsory little effort will be made. In the South Sea Islands, where the climate is a perpetual summer, where clothes are worn for ornament only, not for warmth, where the bread-fruit tree grows wild, and nature provides all other food needed for sustenance and pleasure without effort to him who wants it, the natives spend their days in a half-dreamy state of indolence—dance, swim and play their lives away like children, diversified only by fighting with the neighboring tribes like themselves. Often they have acquired cannibalism, not from a scarcity of other animal food nor as a religious custom, but simply from their delight in such delicious dainties. Having had no incentive to exert themselves, they have never done so, and have therefore remained without improvement—savages in an earthly paradise.

The stimulus to labor or to advance affects but lightly those who in our midst inherit undue selfishness, or those who being born to better things have drifted into vicious habits: many of them acting upon the maxim, "Let him get who has the might, and let him keep who can," need the repressing hand of the law to protect others from their greed and to punish those who have offended. Under the operation of Nature's laws punishment comes, not vindictively, but as the necessary consequence and direct result of the infraction of laws intended for the good of all; the punishment usually follows irrespective of the motive of the law-breaker. Plague, pestilence and famine came, and still come, because cleanliness and the laws of hygiene have been neglected, not as the vengeance of a higher power. Such direct consequences, if possible, should follow the institution and operation of human laws, not "An eye for an eye and a tooth for a tooth" in angry retribution, but as the inevitable result of the violation of laws that must be kept for the good of all. Man's punishment for crime should have but two motives: deterrence of others from crime by the fear of punishment: and the prevention of its recurrence by the same person, for a time or forever, by imprisonment or by death. The deterrence of crime depends very much upon the certainty and the rapidity of punishment after the deed, both of which in this land are woefully deficient, sympathy for the criminal, sentimental folly and delay too often intervening. Legal punishment is considered by many people too much as an act of vengeance; such it should never be, but, like the punishment that nature brings, it should be surely, relentlessly and swiftly administered.

CHAPTER XXX

FEAR FOR THE FUTURE—THE DREAD OF DEATH —RETROSPECT OF LIFE—THE GOSPEL OF EVOLUTION—THE QUESTION OF A FUTURE LIFE.

"So live that, when thy summons comes to join
The innumerable caravan that moves
To that mysterious realm where each shall take
His chamber in the silent halls of death,
Thou go not, like the quarry slave at night,
Scourged to his dungeon, but, sustained and soothed
By an unfaltering trust, approach thy grave
Like one who wraps the drapery of his couch
About him, and lies down to pleasant dreams."*

Our progress through life is marked with many pleasures, but also with many sorrows. Pain or suffering are more positive in their impressions on us, so much more keenly felt than anything we call happiness, that the remembrance of the former and the fear of its recurrence, often blots out all hope for the latter. The sorrows caused by anxiety in our business affairs, the fear for the health of those we love, and, above all, the dread of losing them by death, throw dark shadows over all but our youthful years. Of these sorrows many arise from the anticipation of trouble in advance, but which trouble may never come. Yet this anxiety or fear for the future is the needed guide through life—the replacement of instinct by reason. Our advance in intelligence often brings to us griefs that in their ignorance our remote ancestors never felt; our reason, like Cassandra, prophesying evils, it is impotent to prevent.

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* Thanatopsis—W. C. Bryant.

So far as the dread of death affects us, excepting in those on the threshold only of adult life, it is the fear of losing those we love, rather than fear for ourselves. To the young man or maiden only now grown up, rejoicing in health and strength, it is often a horror to think even of their own death. They cannot realize its possibility. To those later in life its constant recurrence familiarizes the thought, and it is calmly considered as the indefinite yet the inevitable, but even in sickness with little fear, and often looked forward to as a release from sorrow and a welcomed rest. The sudden approach, or the threat of a violent death, calls forth, of course, instinctive efforts to avoid it, but in other cases its coming is usually borne with resignation and with fortitude. But the overpowering sorrow that Death ever brings is that of losing forever from our lives those we love; it thrills us with dread. No grief can equal this; all other ills are then but trivial. When the parting comes, the emptiness of life, the aching void, the absence of the one that is gone, nearly breaks the heart. The closer the tie that bound our lives together, the deeper the sorrow in their severance; very many have prayed then for their own death—many have sought for and found it. When the dying one has suffered much, death is often welcomed as a release both to the dying and to the living. The one to be at rest; the others to know that his sufferings are ended. On the eve of a long separation, the one who suffers most is he who stays in the deserted home; the departing one leaves for new thoughts and scenes in the life beyond; so should we try to think of those who cross before us, to the unknown shore.

The Evolution of knowledge within the last hundred years has not only done much to mitigate suffering to the living, but has saved from death and returned to a continued long and happy life hundreds of thousands of those who in the olden days must have died inevitably. Vaccination, discovered and introduced by Dr. Jenner, has nearly extirpated one of the most frequent, frightful and fatal diseases that ever afflicted man. The germicidal treatment introduced by Sir Joseph Lister in Surgery has kept a countless number from an early grave. Anæsthetics have taken away pain and the fear of pain from the surgeon's knife, and relieved woman of the suffering that, according to the Hebrew myth, God put upon her as a punishment. Death in itself is not an evil, intruding needlessly into the world; it is only its premature and avoidable occurrence that is so. It is the provision that renders possible the entrance of each young, fresh life. In the course of Nature, the young should live to grow old; but we know that in this life, Death not only *will* come, but it *must* come. The progress of humanity, the maintenance of the highest type of the living, is dependent upon the offspring slowly but surely improving beyond the parent; not in a few rare and individual instances from time to time, but in the general advancement of all. This cannot be, excepting by the race of man being kept ever in full vigor by the displacement of the old lives by those young, and, we trust, better ones, born of us.

We, who in the sunset of life look back from the summit of old age to the beginning of the road we traveled on in youth—that road that seemed so endless then, but that now seems so short—we can see that many of the obstacles we stumbled over, have been stepping-stones in our path to a better life. We can see the errors we have made, and the physical and moral dangers we were saved from, often by no saving virtue of our own. Our failures even have led to ultimate success. Above all, we can see that if we had only known what we *might* have known how much sorrow would have been spared to others as well as to ourselves.

We can now fully recognize the change for the better in man's welfare since we were young men, many years ago. Without considering the changes that have made alike the poor and the rich more comfortable, the greater benefits to all men are beyond all number. As the end of the seventeenth Century closed the delusion of the belief in demoniac influence and in witchcraft, and stopped the torture and the frightful death of its helpless and innocent victims, so this closing century witnesses the lessening and disappearance of other errors. In most of our Colleges are now taught, approvingly, the truths that half a century ago would have insured dismissal, and that three centuries ago would have brought the teacher to the stake. The old belief in idealism and a-priori reasoning has well-nigh died out, and most of the learned men of all the world turn from mere metaphysical reveries, or from the dogma of an angry and vindictive Judge, to the study of the works of the living God, and to the manifestations of His power in the guidance of the human intellect and in the execution of His will.

The study of the course of Nature has shown conclusively that this life is the process of evolution, from a lower, imperfect condition of existence to a higher and a better one. The study of the history of the past ages proves the same truth. The knowledge of to-day is not the repetition of the vague and uncertain theories of days long past—of the men who thought themselves the sole custodians of truth, and who gave to the dungeon or to death all who dared to differ with them.

We now know that the truth in all things can be learned only so far as our minds are capable of understanding the facts and phenomena presented. We know that our faculties are limited; the ultimate nature of all things is beyond our comprehension. Science teaches Man humility by showing him his place in nature. Though he may think himself in "Apprehension how like a God," in reality he is only the "Paragon of animals." Neither to the individual man nor to any assembly of men is it given to speak with absolute authority—to be infallible. What in the limited extent of human knowledge is to-day considered established, may to-morrow, by better knowledge, be overthrown. The truth, as known to Science, is always open to correction.

The Philosophy of to-day, the outgrowth of Scientific knowledge, rests, as we have endeavored to show, upon the sufficiency of the evidence produced. To most thoughtful men of Scientific training the testimony that Nature offers is convincing. There is one ever-acting, all-sustaining, wise, intelligent power, in whom we live and move and have our being. Nature as an Entity has no existence. Nature is merely the personification of the past and present acts of the ultimate power and volition that governs all. To think of Nature as apart from, and not a part of, the First Cause—God—is to believe (in the words of the Athanasian creed) that "there is not one Incomprehensible, but two Incomprehensibles." All that we know of God, or that we can possibly know in this life, is to be learned by the observation of His works, including therein the life, history and intelligence of man as a part thereof. In stating that the power which governs the universe is not apart from nor outside of nature, but in nature, no essential predication of the attributes of God is involved or intended. The metaphysician, in defining the Absolute, projected only his own ideas therein. Spinoza reduced all existence to Substance; made God, the Absolute Being, the thinking and extended Substance; nominally of infinite attributes, but by Spinoza's negations leaving only a vague idea of eternal intelligent inactive existence. Science avoids this error. It is folly and presumption in us to try to comprehend the abstract nature of the existence of God apart from his manifestation in his works. To study the operation of his laws governing the physical, mental and moral life on this earth, and when we know the laws to obey them, is our duty and is the extent of our capacity. To live rightly in the life given us, and then to trust our near and our ultimate future to the disposal of Him who gives all life; should be not only our philosophy, but may well be also our religion. As Edwin Arnold wrote, quoting the words of the young Hindoo Mother—

> "But for me
> What good I see humbly I seek to do,
> And live obedient to the law, in trust
> That what will come, and must come, shall come well."

To many men and to most women a philosophy which satisfies wise and thoughtful men is not enough. They ask for something that appeals more to the emotions; that is more capable of outward demonstration and ceremonial observance; in other words, that is anthropomorphic. Early associations, early education and the force of habit make pleasing and desirable to many minds beliefs and customs that Science does not consider within its province. But whatever more may be wished for, and believed in, can only *supplement* the great truth which Science teaches; the early lesson that all should learn.

"Let us hear the conclusion of the whole matter. Fear God and keep his commandments, for this is the whole duty of man. For God shall bring every work into judgment with every secret thing, whether it be good or whether it be evil."

"Then shall the dust return to the earth as it was, and the spirit shall return unto God who gave it."

Thus nearly 2,500 years ago, Koheleth ended his mournful wail over the vanity and the emptiness of life. The knowledge of the present day can give a purpose and a meaning to that life in which he found none. The duty in life and the end of life are the same to us now as it was then; not all enjoyment and not sorrow, but to make our life and all lives wiser and better.

Science makes no pretence to raise the veil beyond the grave. Few analogies that this world has shown are applicable to that "country from whose bourn no traveler returns;" but Science knows no reason that if our lives were rightful when we lived, why they may not be renewed in a life to come. The answer is not *for us*, but *for God to give;* whether for each one or for all. We may rest assured in the belief that if it will be for our good, if it *will be better so*, the life hereafter will be given. That which is best to do will be done. Our individual personality would depend upon the preservation of memory. If every trait of our present lives were reproduced, but with forgetfulness of the past, our identity would be gone; it would not be *ourselves.* We might repeat a life such as we had lived before, without knowledge of it, and without knowing those we had loved and lost. But as our own actions mainly make our lives, the memory thereof, if retained, could then make for us an actual Heaven or a living Hell. In this life the brain bears record in its imprints of our thoughts and volitions. Conscious or unconscious cerebration will reproduce in memory much of that which is long past and gone. Our poor relations, the birds and beasts, transmit to their offspring those imprints that lead to acts which we call instincts; they are inherited memories. A new life hereafter, reproducing in another and a higher brain the duplicate records of an earlier brain, would be a resurrection of the life that is gone. Of course, no *assertion* is intended to be made; the conjecture only that it might be so, suggests that if God so wills, a future life would be a miracle, no greater than the life we live.

The teaching of early Christianity, of St. Paul, many of the patristic and other writers, was not the *survival* of the soul after the death of the body, but the *resurrection* of the body and the soul—the giving of *another* life to the body and the reborn soul.

The Gospel learned from the doctrine of Evolution is that the *virtues*, as well as the *sins* of the father, are often transmitted to the children long beyond the third and fourth generation. It further teaches that the trials and troubles of life are not needlessly given, but that they are the prompting causes and incentives that lead to a higher existence. We may reasonably believe that the same endeavor on our part to make the *Good*, while in this life, still *better*, may fit us, if it shall be in the providence of God, for a future life in a better world to come.

The physical conditions of another life might be very different from those now on Earth. Here, Death and Life walk hand in hand. We are animals *born* to die. This world in time may also die, or be unfit for all Life as we now only know it; but there are countless millions of other worlds. On many of them, although there may be those who live as we live and die as we die, yet it is also true that with them a time may come when their Sun's light and heat shall fade, and that of all other Sun's—the stars—die, too.

The form of energy on which organic life here depends—the disruption of Carbon Dioxide and its reformation—would be impossible then; but that Intelligence that never dies might find expression in conditions that we can conceive not of. "In my Father's house are many mansions." Here we live as but for a day, then pass away; and with our life pass away our weaknesses, our follies and our crimes. We and they—gone forever! But if while living there is that within us that is worth enduring, may it not be found worthy of a non-perishable life, wherein the errors and the follies would not enter? For in that life only those would live who had been *proved*—who were fitted for an existence in which there could be no corrections, no removals by death—a reunion with those they have loved; an Evolution even then continued to still wider knowledge, and eternal life.

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